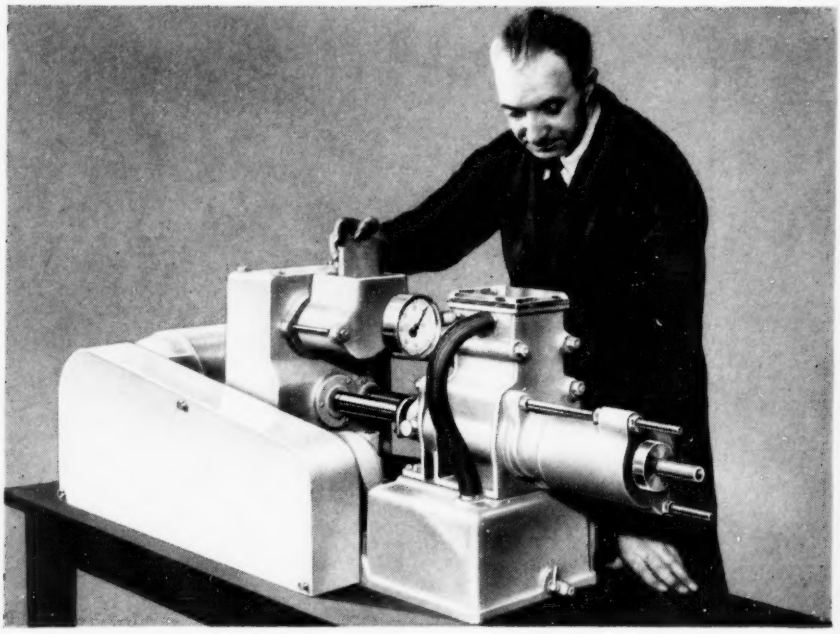
CERAMICS

AUGUST
1953

No. 54 Vol. V



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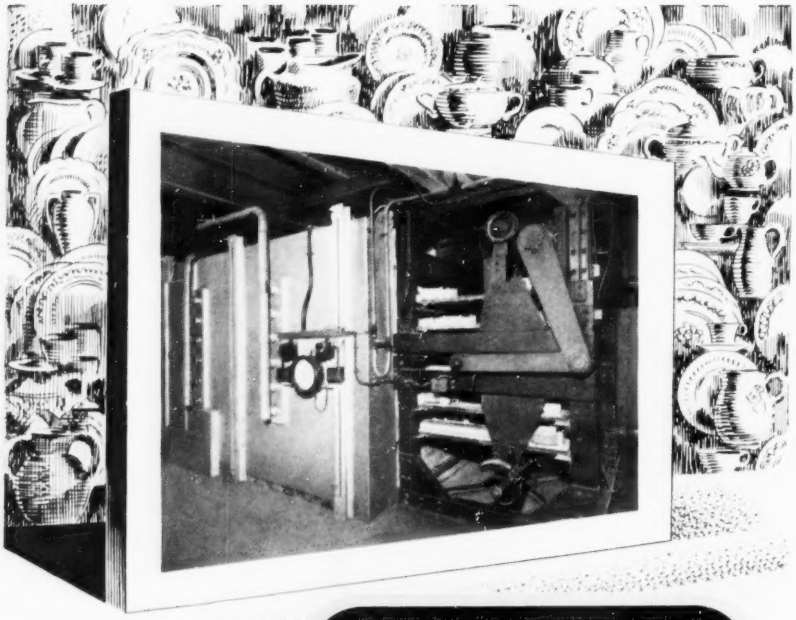

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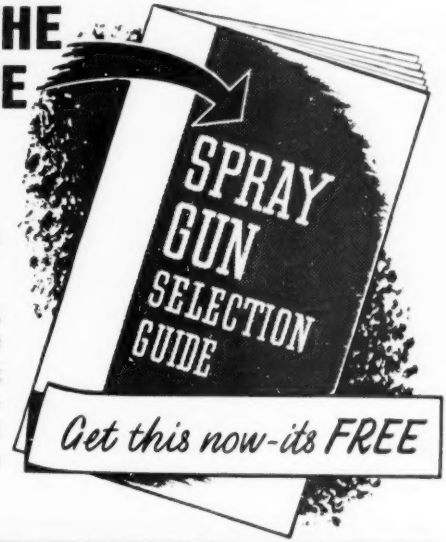

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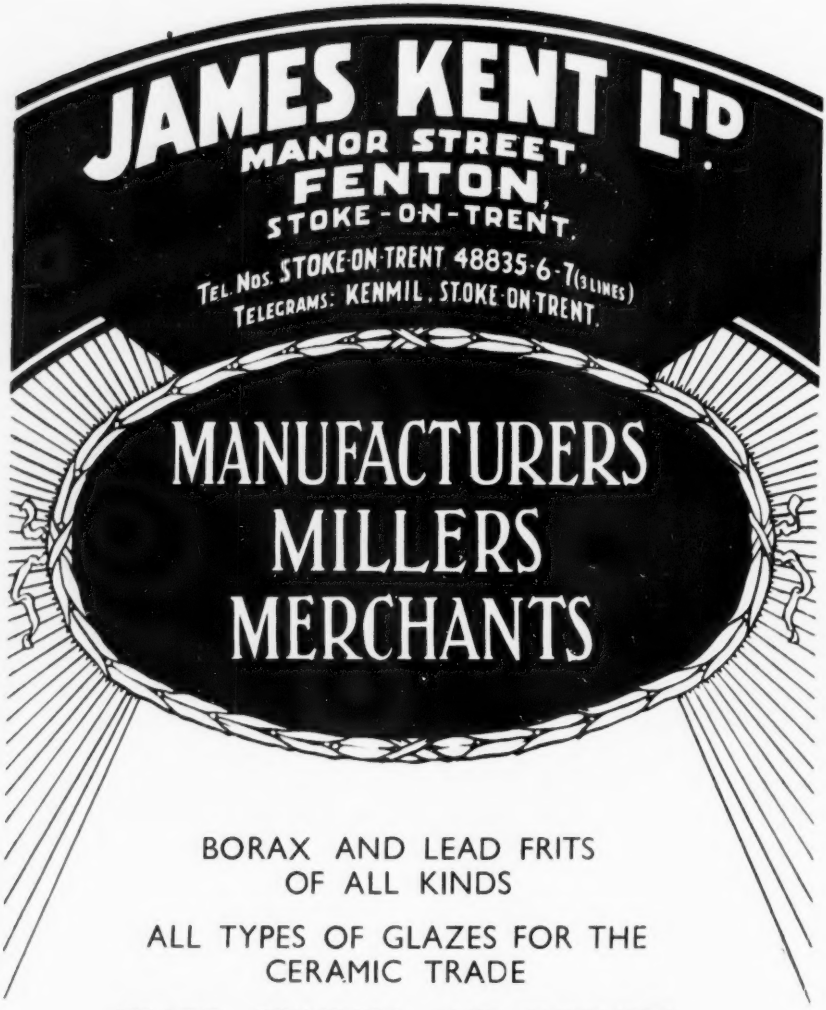

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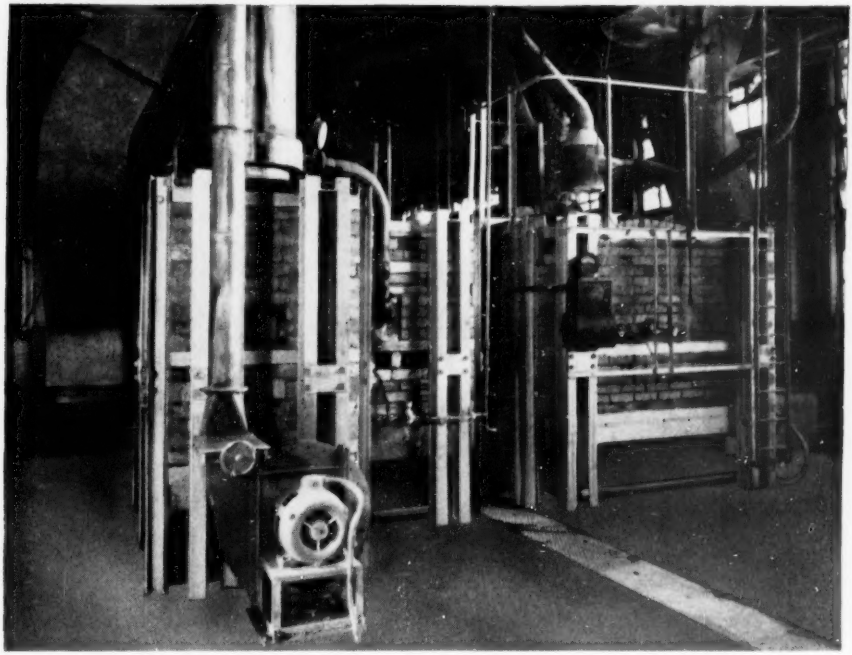

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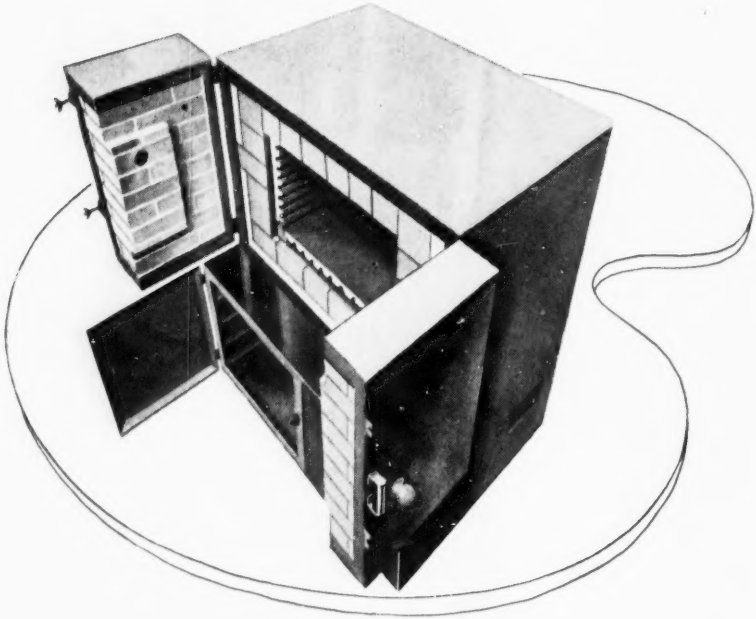

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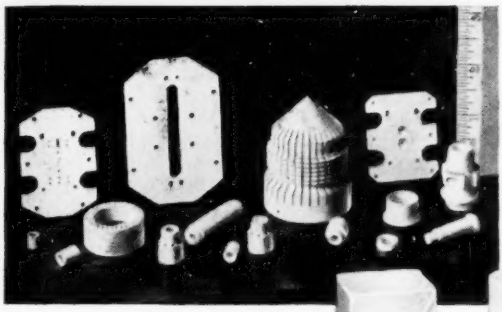

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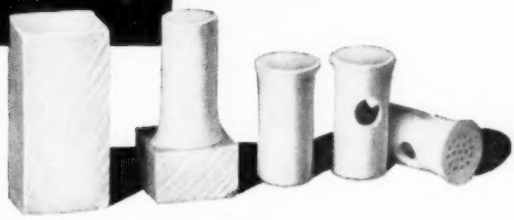

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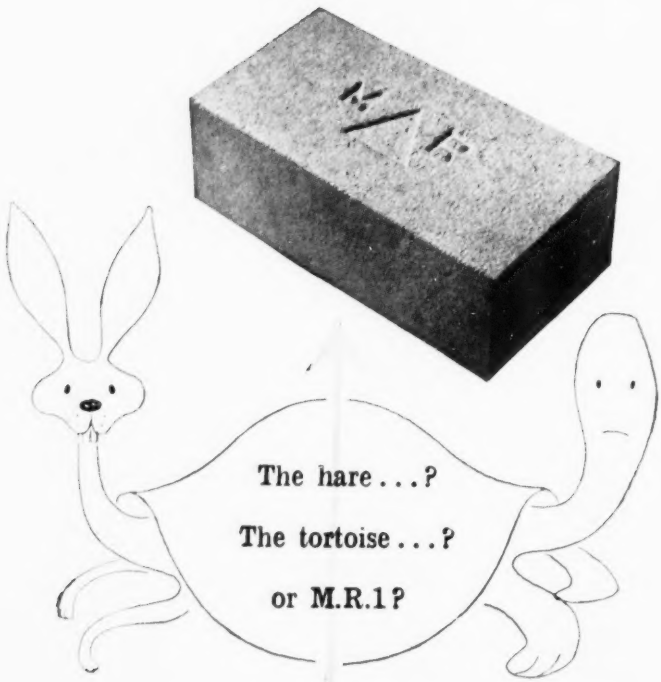

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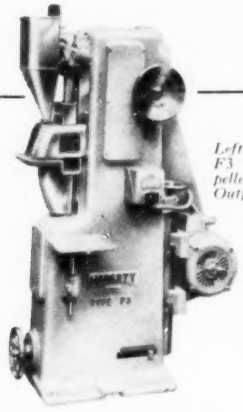
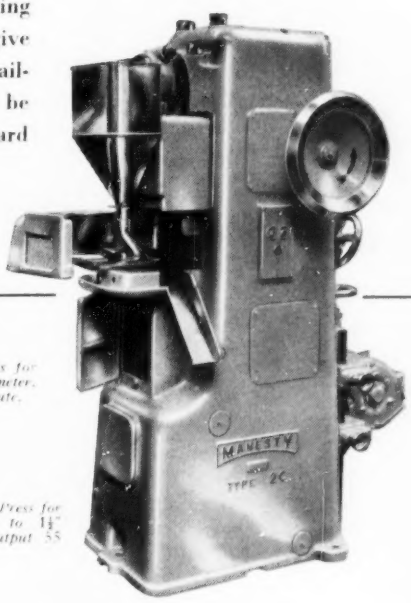


Left:
F3 Pelletting Press for pellets up to $\frac{3}{4}$" diameter. Output 85 per minute.



Right:
2C Pelletting Press for pellets up to $1\frac{1}{2}$" diameter. Output 55 per minute.

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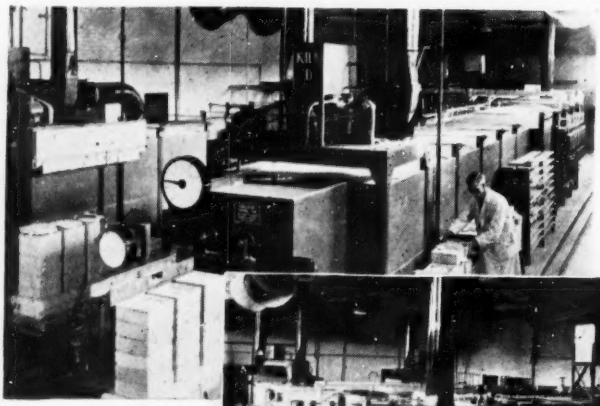

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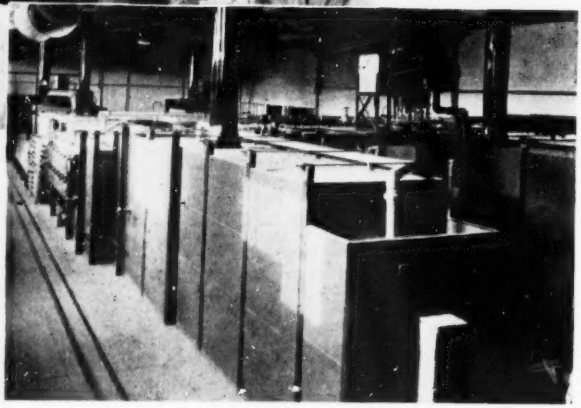

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CERAMICS

AUGUST 1953

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Ceramics

VOL. V AUGUST, 1953 NO. 54

COMMENT

by ARGUS

THERE have been some discussions between the British Pottery Manufacturers' Federation and the Midlands Area Electricity Consultative Council regarding the electrical tariffs for kiln firing.

Mr. E. J. Rowberry, at a meeting of the Midlands Area Electricity Consultative Council proposed that the Council agree to the Pottery Manufacturers' Federation meeting the chairman of the Electricity Board. The motion was seconded by Sir John Kent, who thought that this action would go a great way to solve the difficulties. Colonel Kent was certainly not anti-electricity for he said that development of firing kilns by electricity was likely to be rapid and he thought it ought to be encouraged. He confirmed that it was not the whole consumption of electricity that was concerning the pottery industry but merely that which was used for firing the kilns. Both speakers were accused of "side-stepping the Council." It was suggested that the chairman of the Consultative Council should be present at the interview. In the end the chairman of the West Midlands Electricity Board agreed to meet members of the British Pottery Manufacturers' Federation on the question.

Basically, one would have thought that any Consultative Council which, in the end, is supposed to be a consumers' council, would have been only too pleased if any means brought satisfaction to their customers. It cannot be stressed too often that the customers of the Consultative Council are, indeed, the public.

One has merely to read that 5,000 fewer people were employed in the pottery industry at the end of last year than at the end of 1952 to realise how much the public is concerned with matters such as electricity tariffs.

Dr. Stross, Stoke Member of Parliament, thinks that the prospect of peace in Korea will certainly bring us nearer an era of fierce competition from Japan for the pottery export markets. In this respect it must not be forgotten that behind the Japanese recovery is a tremendous importation of American skill and American technique. Till now, this has been largely used to provide armaments for the Korean war, but with the end of the war Japan, for survival, must turn to its normal industrial strength which is, of course, pottery, textiles, cheap machinery, cheap watches and cheap cameras.

Apart from the necessity of the

pottery industry obtaining protection from the Government in an attempt to obtain lower tariffs in the United States and Canada as well as international copyright agreements, it does need protection from the Government-sponsored industries such as coal, electricity and gas, in an effort to maintain a reasonable quality/price structure.

The more one reads of the activities of Consultative Councils which are supposed to be the mouthpiece of the consumer, the more one realises that they are in many cases acting as a buffer, preventing the consumer from getting to grips direct with the fuel board concerned. It is not only electricity which causes the British Pottery Manufacturers to complain. The same thing applies with gas, which is an important fuel to the pottery industry.

But over and above all this there is the spectre of coal. We have been referring to the inadequacy of the Electricity Consultative Council to protect the industrial electricity consumer but, indeed, when it comes to coal the position is even worse. The annual report for the Industrial Coal Consumers' Council has been issued for the year ending the 30th June, 1953. It is, indeed, a dismal document. It warns industrial consumers to spare no effort in economy, in fact it goes on to say: "We are satisfied that if consumers did what they could there would be no shortage of coal either for home consumption or increasing export."

This is the Coal Consumers' Council speaking on behalf of its delegates—industry. If any Trades Union leader had the audacity to speak like this, the platform on which he stood would be torn from under his feet.

No Public Record

Worse still, this Industrial Coal Consumers' Council says: "We wish to reaffirm our previous decision that because it is inevitable that questions involving Government policy are apt to be raised on almost every matter that comes before us, it would be impossible to hold any of our meetings in public without impairing their usefulness."

In fairness remember that gas and electricity are industrial consumers of coal. With electricity, coal costs amount to about 70 per cent. of the cost of generation. In the case of gas it is not quite so high but still substantial. In fact, just as the pottery industry seems to have no control over the price of the fuel it uses so the gas and electricity industries—bear in mind the scientific part of fuel, for no one ever attempts to suggest seriously that science has had, as yet, any impact on the coal industry—are held in check. At least with gas and electricity the meetings of the consultative councils are not top secret affairs. But when it comes to coal, the root of all fuel problems, there is no public record of what the members of the council say. How, indeed, can industry ever expect to have its problems seriously considered by its own Consumers' Council under such conditions.

Shortage of Skilled Labour

It is becoming increasingly obvious that there is something seriously wrong with the coal industry—maybe its lack of productive ability is not the worst feature. Firstly, it bitterly opposes anyone enquiring into or looking at its books even though it admits that it has an extreme shortage of skilled engineers. There is no doubt that this shortage of skilled labour in the National Coal Board is one of the greatest factors activating against a satisfactory coal industry. One gathers that to refute the argument that it is not overloaded with officials the National Coal Board boasts that it only employs 42,000 "white collar" workers to cover some 700,000 manual workers—about 5 per cent. instead of the customary 15 per cent. in industry in general.

Surely it should be appreciated that a pointer towards productivity is the higher proportion of skilled thinkers, "white collar" workers, call them what you will, in relation to manual workers. One of the objects of development in production is surely to replace expensive manual labour by productivity aids in the form of mechanised processing and handling. When this is done quite obviously the proportion of "white collar" workers to manual workers rises. In short, if the Coal Board insist it only qualifies in the 5 per cent. category against the common practice of 15 per cent. it is tantamount to admitting that it is some 200 per cent. behind the times, which really strengthens the case for

some kind of investigation into its activities.

It is not a good policy that the whole of the fuel industry should be very largely controlled by the National Coal Board. By the Coal Act there is room for autocracy in Hobart House, London, and another autocracy at the headquarters of the National Union of Mineworkers. One is not saying that these autocracies prevail, but in the present organisation there is nothing to prevent them from doing so. There again it is impossible for the public to learn anything about the National Coal Board except that which it wants them to hear, because of the secrecy maintained at the meetings of the Consumers' Councils. The Coal Board is in the position of being able to tell the electrical industry what coal it can have. It can restrict the supply of coal to the gas industry and it can make momentous decisions in a purely arbitrary fashion. It would not matter quite so much if it were only the coal industry that was affected, but because Britain depends upon coal for most of her fuel any inefficiency or under-productivity in the coal industry is multiplied time and time again throughout industry.

Blazing Fire

In this day and age when the medical profession agree that bronchial troubles are more prevalent in smoky areas—when a committee on atmospheric pollution has just been formed—and when time and time again in a variety of reports beginning with the Simon and ending with the Ridley it has been emphasised that coke is more efficient in use than coal, it is surely fantastic that the National Coal Board should only be interested in burning coal. In fact it pours large sums of money indirectly into a deliberate encouragement of the nation to burn coal rather than process it. Even the current issue of *The Review*, published by the Coal Utilisation Council, has as the title of its opening article: "Wanted: a Blazing Fire."

In short, it would appear that the National Coal Board is rather inclined to work with the orthodox distributors of raw coal and to encourage them. This may have been all right in the pre-war days when there was real competition between coal, electricity and gas, but in this day and age it is a fantastic state of affairs. With one hand the National Coal Board will spend some £250,000 to encourage fuel efficiency, whilst simultaneously it encourages through the Coal Utilisation Council extravagant waste. Quite obviously it would appear as sensible that coal should be processed in gas works or carbonisation works to obtain the two smokeless fuels, coke and gas, as well as a variety of chemicals which would otherwise have to be imported. Yet one gathers that there has been a restriction on the supply of coal to the gas works, which operates in two ways. Firstly, less coal carbonised means less coke. In addition, the coke in the gas works, in the absence of coal, must be used to produce gas at a thermal loss in the form of water gas, to make good the supply of gas not available because of the lack of coal.

Surely this is a ridiculous state of affairs and is never likely to solve the problem of smoke abatement and efficient fuel usage.

CRYSTAL MEMORIAL CUP FOR DUTCH AIR FORCE

IN conformity with a custom, which seems to becoming established in Holland, of marking an occasion by presenting a suitably designed and executed memorial cup made by one of the leading firms of Dutch crystal manufacturers, a beautifully engraved memorial cup has recently been presented to the Royal Dutch Air Force by the Royal Netherlands Aircraft Industry Fokker Ltd., Amsterdam. It commemorated the former's fortieth anniversary.

Designed by the Dutch artist Willem Heesen and representing, in the stem, the war god Mars reaching up to the bowl, where units of the Air Force are flying among the clouds, the cup was executed by craftsmen of the Royal Netherlands Glass Works "Leerdam," Leerdam, Holland.

This same artist and glass manufacturing firm have recently produced a crystal goblet as a wedding present for Princess Josephine Charlotte of Belgium and Prince Jean of Luxemburg. It was given by the Amsterdam Benelux Committee.

Incidentally the latter firm has, this year, celebrated its seventy-fifth anniversary, and to mark the occasion, the Netherlands Glass Museum was opened at Leerdam. A large collection of glass pieces are on exhibition there.

The Works Laboratory

by

W. L. GERMAN, M.Sc. Ph.D.(Lond.), F.R.I.C.

ONE is frequently asked to advise on equipment for the works laboratory, and sometimes on how to start establishing one. In the first place the manufacturer should understand exactly what tests he proposes to do, and what results of value he is likely to obtain. He should also assess whether it would be cheaper to have these carried out in a testing laboratory adequately equipped for the job, such as those run by the N. Staffordshire Technical College and the British Ceramic Research Association at Stoke-on-Trent in this country.

Experience shows that even today, in some quarters, there is a tendency to look upon a laboratory as a kind of magic box which can solve all production problems, and it is necessary to emphasise that laboratory results can only be applied with greatest advantage by skilled personnel on the factory floor, and if these are not available the services of a consultant may be required.

Assuming that all these points have been discussed at director level, and it has been decided that the cost of running a laboratory is likely to be recovered by reduced losses, and improved quality in the manufactured article the points that then arise are what work shall be carried out, and what equipment will be necessary.

A laboratory can be a very elaborate and expensively equipped place, or equally a small room doing only a few tests. It does not follow that a very expensive laboratory will necessarily turn out more valuable results to the firm than a much less pretentious place; much will depend on the man in charge.

Except in a very large organisation fundamental research problems are best left to a research association, and the works laboratory's efforts restricted to improving production.

In most works the task of the laboratory can be roughly grouped into the following categories:—

(a) Control testing of raw materials.
(b) Control of the manufacturing process.
(c) Tests on the finished product.
(d) Simple experiments, such as those required when new articles are to be put into production, or when the cause of some trouble in production is to be traced.

The Building

The laboratory building will often have to be an odd room for a start, but as the work develops and its usefulness is proved it may be necessary to erect a new building. In any case the main essentials are good lighting and a supply of gas, electricity and water. If compressed air is used on the factory a supply taken to the laboratory is often useful.

Benches nowadays can be quite expensive, especially if metal units or hardwood tops are specified. If chemical analysis is contemplated benches with tops such as teak, which resists corrosion, are still considered the best in many quarters. Where the testing is mainly of a physical nature, such as grain size determinations, a deal bench erected by the works carpenter, and possibly covered with sheet zinc, may be quite satisfactory. The use of small rickety tables has little to recommend it—sooner or later they may be knocked over, and this will always happen when some important determination is in progress!

If dusty operations are to be undertaken adequate arrangements for removing it must be provided, and channels in the floor for washing down may be essential for some operations. Between the drains and the outlets from the laboratory sinks a settling tank should be built, so that clay and other material likely to cause

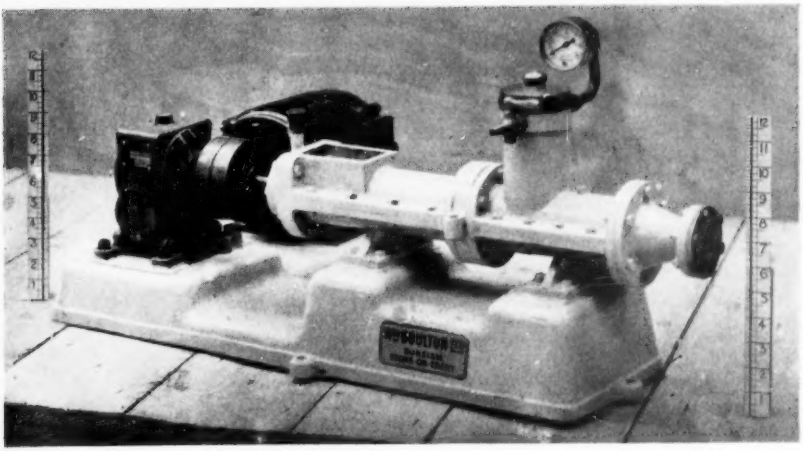

Fig. 1. Small de-airing pug mill suitable for extruding small bars and tubes

(Courtesy: Wm. Boulton Ltd., Burslem.)

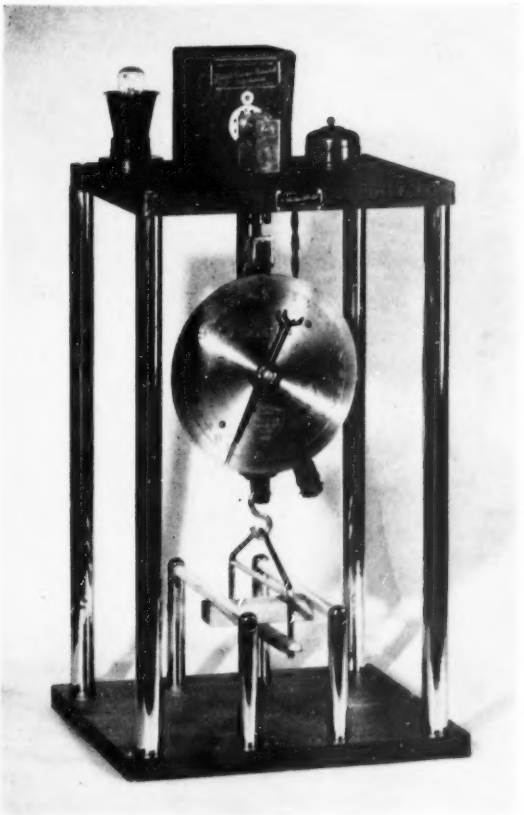

Fig. 2. Modulus of Rupture machine, by F. Malkin and Co. Ltd., Longton

(Reproduced by permission of the Director of the British Ceramic Research Association)

trouble can be trapped. Having put this in make sure that it is someone's job to clean it out at regular intervals. One still sees laboratory sinks connected to iron down pipes. If acid is likely to be discharged these will quickly need replacement with some acid-resisting material. Chemical stoneware is best, but if the appearance does not matter the ordinary salt-glazed pipe is cheaper.

In a laboratory which is designed to do very special work it may be necessary to construct special rooms for certain types of equipment such as X-ray apparatus, but in most works laboratories this will not arise. Physical experiments should not, however be done in an atmosphere exposed to chemical fumes, if only for the sake of the apparatus, and if much heating is to be done everyone will be more comfortable if the furnaces are collected in a separate room or building.

Equipment

The equipment used in ceramic testing laboratories is very varied, and in the limits of a short article it is impossible to give a catalogue of all the material available. The best plan appears to be to treat the matter under the headings given above and to consider what apparatus is available for testing raw materials; control of the manufacturing process; control of the finished product; and small scale experiments for pilot production.

Control of Raw Materials

Under this heading one must consider the usual ceramic raw materials, clays, flint and silica sand, felspar and Cornish stone, together with special materials of interest to the refractories industry. The analysis of fuel is also undertaken by some manufacturers.

The aim of analysis of raw materials is to spot variations which may be troublesome in manufacture, and to to see that the material supplied complies with an agreed specification as regards quality. Unfortunately the analysis of most ceramic materials has hitherto been such a long job that it usually only served a post-mortem purpose. Recent work however, has made an analysis of clay possible in less than a day,[1] and large concerns may in the future undertake clay analysis more frequently. Most smaller concerns will not equip themselves for this, but will rely on the analysis given by the supplier.

Experience has shown that with many ball-china clays the variation over a period of years is not large. Where analytical work is to be undertaken the fitting up of the laboratory may cost several hundreds or even thousands of pounds.

A balance room and balances will be required. Scales and balances for rough weighings are comparatively cheap. It is now possible to get cheap balances of the students type which dispense with need for fractional weights—always a bugbear in a laboratory and a source of wasted time. For more accurate and quick weighing such as required in analysis a better balance is required and may cost in the region of £100 or more. In addition silicate analysis requires platinum vessels, and a minimum of £150 may have to be expended on this, though the platinum can, of course, always be sold again. Added to this is all kinds of glass-ware, and various laboratory equipment, fume cupboards, and chemicals, and soon a formidable expenditure can accumulate.

Physical Tests

Physical testing of clay is much quicker and simpler, and is the routine control that appeals to most works laboratories. Green strength of clay is important, since lack of strength in unfired articles may lead to excessive losses in those operations which lie between making and putting in the furnace for firing.

This is usually tested by determining the modulus of rupture. Experience shows that the most consistent results are obtained with bars extruded from plastic clay, and dried under a controlled slow drying schedule to avoid hair cracks. The bars may be made in a machine supplied by Messrs. Malkin of Chadwick Street, Longton, Stoke-on-Trent, or from a small pug mill as supplied by Messrs. William Boulton Ltd., Burslem, Stoke-on-Trent (Fig. 1). With the latter the clay can be de-aired. Those who have the facilities can also make a simple apparatus in an engineering shop. For breaking the test-bars the load should

be applied at an even rate.

Messrs Malkin manufacture a machine devised by the British Ceramic Research Association (Fig. 2), and there is also a very good machine made by Messrs. T. C. Howden of 12 High Street, Leamington Spa. These machines are very convenient to use, but if for financial reasons one is not available, the alternative is to place the bar on two hardwood supports, and apply the load by means of a hardwood bar and stirrup connected to a can into which water is run until the bar breaks. The water must then be weighed to get the applied load.

Those who are concerned with dry mixing need checks on the moisture content of the raw material. This is most conveniently done with the Speedy Machine Tester marketed by Messrs. Ashworth Bros. of Burnley. Briefly the principle is to add calcium carbide to a fixed weight of dust in a sealed container. The acetylene gas generated operates a pressure gauge in the base of the instrument, which is calibrated to read percentage moisture directly. This instrument costs in the region of £20 and determinations can be done in a few minutes with it.

For other tests on clays, such as fired colour, one must use either the works oven or a laboratory furnace. The latter will be necessary if other tests, such as vitrification characteristics, are required, and may be either gas-heated or electrically fired. Most laboratory furnishers such as Messrs. A. Gallenkamp and Co., Griffin and Tatlock Ltd., Baird and Tatlock Ltd., London, supply such ovens, and in addition there are now various firms manufacturing laboratory and studio potters' electric ovens of all sizes suitable for firing bricks and pottery. These vary in price from £30 to £40 to over £200 depending on the size. Pyrometers and temperature recording gear may cost £30 to £40 extra. Firms making small electric ovens include Messrs. British Ceramic Service Co., Stoke-on-Trent, Electrical Rewinds Ltd., Burslem, Stoke-on-Trent, Messrs. Applied Heat Co. Ltd., Watford, Messrs. James Royce Electric Furnaces Ltd., Walton-on-Thames, R. M. Catterson Smith Ltd., Wembley, as well as the usual laboratory suppliers listed above. Where higher temperatures in the region of 1,700° C. are required for refractoriness and refractoriness under load tests more expensive gear is required in the shape of electric carbon resistance furnaces with transformer and control gear. The furnaces are made by Steele and Cowlishaw, Cooper Street, Shelton, Stoke-on-Trent. Most of the large electrical firms make suitable transformers and controllers, e.g., Messrs. Ferranti make one, the price of which is in the region of £500.

If the raw material is supplied ready ground seive analysis or grain size determinations may be required. (See following section).

Control of Manufacturing Process

The laboratory is usually called upon to carry out checks on the manufacturing method particularly with the firing process. Checks on firing may require pyrometers and temperature recording gear. For low and medium temperatures base metal thermocouples will suffice, but for higher temperatures the more expensive platinum—platinum—rhodium couples will be required. A portable pyrometer of the disappearing filament type is a very handy apparatus on a works.

A number of firms make satisfactory temperature recording gear such as the Cambridge Instrument Co., James Kent, Luton, Ether Ltd., Birmingham, Foster Instrument Co., Letchworth, Negretti and Zambra, London, etc. These firms list all types of pyrometer including those for special applications such as temperatures of hot surfaces, etc.

Control of combustion by measuring the carbon dioxide content of the flue gases may require an Orsat Apparatus or a Cambridge carbon dioxide meter.

Grain size of materials is always important in ceramic processes since these often involve sintering or partially completed reactions where surface area affects the extent to which they proceed. Schöne elutriators and Andreasen pipettes are used, but in this country the hydrometer method developed by H. W. Webb and S. W. Ratcliffe[1] is now very widely used since a determination can be done in about thirty minutes compared with about twenty-four hours by the Schöne method. Suitable hydrometers can be

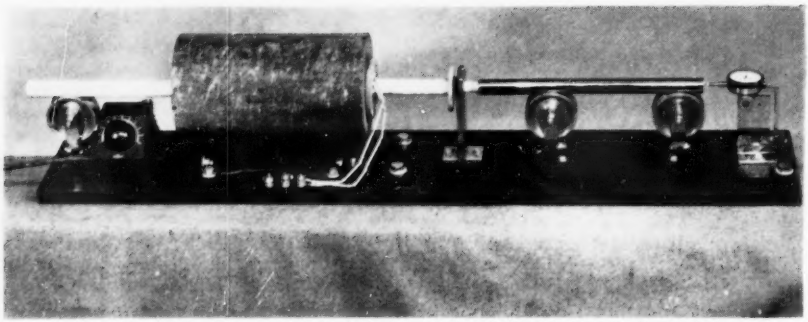

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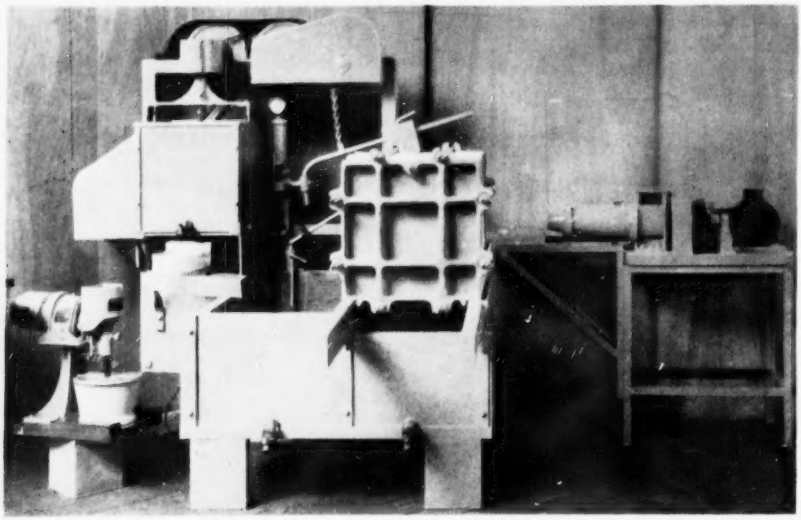
Fig. 3. Apparatus for the determination of coefficients of expansion, by F. Malkin and Co. Ltd.

purchased from the usual laboratory glass suppliers, e.g., Messrs. Towers of Widnes, Lancs. Before use they need calibration, and this is usually most simply done by one of the ceramic testing laboratories, though details are given in the original paper.

Grading of materials after grinding or crushing may demand seive analysis. For this some mechanical arrangement such as the Rotap Sieve is of great advantage. Sold by International Combustion Ltd., Derby, or 19 Woburn Place, London, W.C.1.

Some pottery firms make a practice of checking the consistency of their plastic body by determinations of modulus of rupture each day in the manner outlined above for clays.

Casting slip needs regular checks if the fluidity and casting rate are to be maintained, particularly as scraps are often used in making it. Some kind of viscometer is a useful method of checking the quality of casting slip, and for a long time now the industry has used the torsion wire type as a yardstick for this purpose, such as the



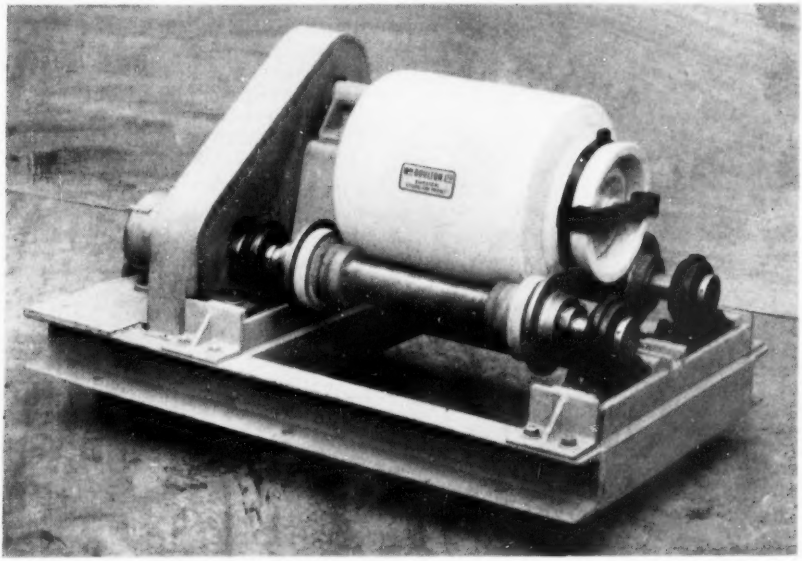
(*Courtesy: Wm. Boulton Ltd., Burslem.*)

Fig. 4. An experimental blunger and filter press, with (right) small pug mill, and (left) small grinding pan

Technico Torsion Viscometer supplied by Messrs. A. Gallenkamp and Co., London.

Needless to say pint weight determinations are also required. The usual method is to weigh a copper pint pot full of the slip on a suitable pair of scales, but the result would undoubtedly be more accurate if it were possible to weigh a larger quantity of slip.

Dust pressing will involve frequent checks of the moisture content of the dust, and of the hardness of the pressed article. The former can be done with the Speedy moisture tester already mentioned while for the latter the penetrometer made by E. Baty and Co. Ltd., 39 Victoria Street, S.W.1, which consists of a loaded needle attached to a Mercer dial gauge to measure the depth of penetration is convenient.



(Courtesy: Wm. Boulton Ltd., Burslem.)

Fig. 5. Small jar mill for laboratory grinding. These can be made to take several jars at once

Tests on the Finished Product

The tests on the finished product will vary tremendously with its nature and many are controlled by specifications. These will very largely determine the apparatus required in the laboratory.

Pottery may require tests for freedom from crazing, resistance of decoration to acids and detergents, translucency and porosity.

Crazing tests are always carried out at regular intervals especially on porous bodies like earthenware. When a steam pressure of 40-50 lb./sq. in. is available all that is required is a simple autoclave to take the ware so that it may be subjected to the action of steam at that pressure. Different works use different conditions for this test. The main thing is to stick to one test and use that for comparing the probable performance of the ware in service. Any engineering firm will make the autoclave. If steam is not available it will be necessary to generate this in a gas or electrically heated boiler.

Acid resistance demands only the usual laboratory gear. Translucency can only be measured in a comparative way and there is no standard apparatus on the market. Various types of apparatus involving photoelectric cells have been described.[3] Impact testing can be done if required on the Amsler machine marketed by T. C. Howden and Co., of Leamington

Spa. Porosity requires again the usual laboratory apparatus.

Where electrical porcelain is involved the testing gear is very much more expensive and the laboratory will be of a specialised nature. Its equipment may well be a major item of expense.

Refractories may require testing for crushing strength, thermal conductivity, after-contraction, permeability, spalling resistance and coefficient of expansion over various temperature ranges as well as refractoriness. For crushing strength a special apparatus is required such as that made by Messrs. Avery of Birmingham or J. Denison and Son Ltd., Leeds. Its present cost is around £900.

Thermal conductivity apparatus usually has to be made up in the laboratory.

Details are given in technical literature.[4, 5]

After-contraction and spalling resistance involve heating arrangements and a supply of compressed air for cooling.

Coefficients of Expansion

Coefficients of expansion are usually determined in a special apparatus (Fig. 3) involving a fused silica tube heated in a small electric furnace wound round it. A stop is fused into the tube against which the specimen buts, and a fixed silica rod fitting against the other end actuates a Mercer gauge to measure the expansion (cf. Ceramics, January, 1952 (Stresses and Strains in Glazes). The complete apparatus is made by Messrs. S. Malkin and Co., Longton, Stoke-on-Trent, or the silica tubes can be obtained from the Thermal Syndicate Ltd., Wallsend-on-Tyne. Another type of apparatus is that described by G. H. Abbott.[6]

Permeability can be readily measured by an apparatus marketed by Ridsdale and Co. Ltd., Middlesbrough. Apparatus for refractoriness has already been described. Tests on certain types of building brick involve crushing strength and water absorption. Apparatus for crushing strength has already been described and water absorption needs only suitable weighing apparatus. Salt-glazed pipes are usually tested by applied hydraulic pressure. Engineers specialising in pipe-making machinery usually supply the apparatus for this.

Experimental and Development Work

Where it is necessary to mix new bodies and to carry out development work much more equipment will be required, and the cost of fitting up the laboratory increased. A variety of experimental blungers and small scale filter presses and pug mills is made by Messrs. Wm. Boulton Ltd., Burslem, Stoke-on-Trent (Fig. 4). Small experimental pug mills are also obtainable from Messrs Service Engineers Ltd., Cobridge, Stoke-on-Trent and Messrs Rawdon Ltd., Moira, near Burton-on-Trent. Prices of small de-airing pug mills range from £100 to £300 approximately according to size. Small grinding mills are made by a number of firms including Messrs. Wm. Boulton Ltd., Service Engineers Ltd., P. W. Heller 89 Windermere Avenue, London, N.3. (Planetary Ball Mill), Messrs. Sturtevant Engineering Co. Ltd., Cannon Street, London, E.C.4, and Messrs Wilkinson Rubber Linatex Ltd., Camberley, Surrey. The latter make the rubber grinding cylinder which has many attractions for certain types of material.

All types of laboratory size crushers and grinders are made by Messrs. Wm. Boulton Ltd., Sturtevant Engineering Co. Ltd., and W. M. Fuller and Co., Edmund Street, Birmingham. These include jaw crushers, roller crushers, disintegrators, and end-runner mills. Many of the general laboratory suppliers also market these machines. They are very useful when only small samples are required, and where only limited amounts of material may be available.

Cutting of fired ceramic materials is often required in a ceramic laboratory, and has sometimes been a problem. Power driven cutting off abrasive wheels now enable this to be done with ease and such apparatus is that supplied by Clipper Manufacturing Co. Ltd., Leicester, Anderson Grice Co. Ltd., Carnoustie, Scotland, and F. E. Rowland and Co., Reddish, near Stockport. Devices for spraying water on the wheel during cutting are available and these are recommended as a means of avoiding dust in cutting ceramic materials.

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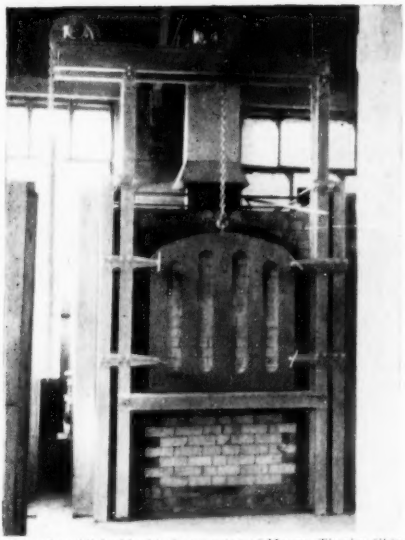

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For dry-mixing operations very good laboratory size mixers of the Simpson type are now marketed by Messrs. August of Halifax, Yorks. The smallest has a diameter of 18 in. and larger sizes are available.

There are now available in this country small bench-type hydraulic presses giving a dead load of two tons upwards. For some laboratories these may be very useful. Details of those available for the ceramic industry can be obtained, for example, from Messrs. Drummond Asquith Ltd., New Street, Birmingham 2, or P. J. Hare Ltd., Wrington, Somerset.

Materials

Ceramic materials for experiments may be required in smaller amounts than the wholesaler will supply. Most of the potters merchants in Stoke-on-Trent can supply some or all of these items.

Importance of Statistical Control

The use of some simple type of quality control chart in connection with routine testing results is something which can be of very definite value, but is often neglected. One does not need to be a mathematician to plot a simple control chart—a youth or girl can be taught to do this quickly.

The advantages of a chart so constructed are that it enables one to plot inaccuracies in the testing method and to remedy them, and also trends in falling off of quality can be spotted and remedial action taken before losses become too high. These charts are especially useful, where a property normally shows a considerable spread in the determined values, as it enables limits to be set scientifically for permissible variations. In this way it is often possible for the management to avoid unnecessary worry or attempts at remedial action when in fact none is called for.

The author has attempted to assist those who may have difficulty in locating laboratory scale machines, by mentioning certain firms whose products have come to his notice. He realises that he may inadvertently have omitted others and, if so, this is regretted.

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BRICKS FROM SLATE RUBBLE

Production of bricks from slate industry rubble will be launched on a limited commercial scale in the near future by Scottish Slate Industries Ltd., at Ballachulish. This development brings to fruition proposals put forward about a year ago for the use of slate waste as a constituent material for bricks for local consumption. Work has been going on steadily towards the perfecting of those original proposals and the company have good reason to believe that a highly successful composition slate-cement brick will be achieved which will prove acceptable to the authorities.

Output will be aimed mainly at the local building industry, where limited transport costs will make the slate-cement brick an attractive purchase.

The successful development of this project would assist in the revival of the Scottish slate industry and help solve one of the major problems in this field—disposal of slate rubble.

THE INSTRUMENT HANDBOOK

THE British Industrial Measuring and Control Apparatus Manufacturers' Association at 21 Tothill Street, London, S.W.1, have produced the B.M.C.A.M. Handbook for 1953. In it is outlined the work of the Association and its collaboration with industry, together with a list of the names and addresses of the members of the Association.

Of extreme interest is the extensive list of products listing individual instruments under the names of their suppliers.

STANDARD REFRACTORY TUBES

In Recrystallised Alumina, Mullite and Aluminous Porcelain

Summary

THE manufacturers of special refractories, with the assistance of the Sintered Oxides Sub-Committee of the Inter-Service Metallurgical Research Council (Ministry of Supply and Admiralty), have added to the list of tubes of standard dimensions published in 1950. The revised standard sizes are listed in Tables 1-5, together with an explanation of the system of tolerances, and additional matter that may facilitate co-operation between the manufacturer and the consumer.

Introduction

A rapid increase in the demand for tubes of alumina, "mullite," and "aluminous porcelain," led to some standardisation of dimensions in 1950 by the manufacturers with the assistance of the Sintered Oxides Sub-Committee of the Inter-Service Metallurgical Research Council (Ministry of Supply and Admiralty). Later experience has resulted in review and extension of these standards, which in their revised form are listed in the Tables. All dimensions are expressed in millimeters. The manufacturers have agreed to adopt this form of measurement as standard for the future.

Tolerances

The adopted tolerances indicate the appreciably greater limitations in the manufacture of recrystallised alumina as compared with mullite and aluminous porcelain.

TABLE 1.—SMALL SINGLE BORE TUBES (OPEN BOTH ENDS) IN RECRYSTALLISED ALUMINA, ALUMINOUS PORCELAIN AND MULLITE

Bore mm	*Tolerance Limits* %	*Nominal Wall* mm	*Maximum Ext. Dia.* mm	*Normal Maximum Lengths* *Recrystallised Alumina and Mullite* mm	*Aluminous Porcelain* mm
1·0	± 20	1·0	3·6	300	450
2·0	± 15	1·25	5·3	450	600
3·2	± 12·5	1·25	6·5	600	750

Other Lengths and Sizes and Tubes with one Closed End. Subject to special inquiry.

Straightness ... ... Maximum deviation from straightness: 1·0% of the length for Recrystallised Alumina, and ½% of the length for Aluminous Porcelain and Mullite.

Maximum Diameter... ... ... Covers all tolerances including ovalness.

TABLE 2.—SINGLE BORE INSULATORS, 25, 50 AND 75 MM LENGTHS IN RECRYSTALLISED ALUMINA, ALUMINOUS PORCELAIN, AND MULLITE

Minimum Bore mm	*Nominal Ext.* mm	*Bore of External Tube Gauges for Lengths* 25 *mm*	50 *mm*	75 *mm*
0·65	2·0	2·6	2·75	3·0
0·9	2·6	3·1	3·25	3·5
1·3	3·5	4·0	4·15	4·4

Other Lengths and Sizes—Subject to special inquiry.

TABLE 3.—TWIN BORE INSULATORS, 25, 50 AND 75 MM LENGTHS, IN RECRYSTALLISED ALUMINA, ALUMINOUS PORCELAIN, AND MULLITE

Minimum Bore mm	*Circular Nominal Ext. Dia.* mm	*Oval Nominal Ext. Sizes* mm	*Bore of External Tube Gauges for Lengths* 25 *mm*	50 *mm*	75 *mm*
0·65	3·0	3 × 2	3·6	3·75	4·0
0·9	4·0	4 × 2·6	4·6	4·75	5·0
1·3	4·8	4·8 × 3·0	5·4	5·6	5·8
1·9	7·5	7·5 × 4·75	8·3	8·5	8·75

Other Lengths and Sizes—Subject to special inquiry.

TABLE 4—PYROMETER AND FURNACE TUBES (OPEN, OR CLOSED ONE END) IN RECRYSTALLISED ALUMINA

Bore mm	Tolerance Limits %	Nominal Wall mm	Maximum Ext. Dia. mm
5·0	±10	1·5	9·0
5·75	±10	1·5	9·8
6·25	±10	1·85	11·2
8·0	±10	2·0	13·5
10·0	±10	2·25	16·0
12·5	±8	2·5	19·0
15·5	±8	2·75	23·0
19·5	±8	3·0	28·0
22·5	±8	3·0	31·5
25·5	±6	3·25	34·0
28·5	±6	3·5	38·0
32·0	±6	3·5	41·5
38·0	±6	4·0	49·0
45·0	±6	4·5	57·5
50·0	±5	4·5	63·0
55·0	±5	5·0	69·0
65·0	±5	5·0	80·0

Lengths. Normally supplied from 300 mm in 75 mm steps to 900 mm long.
Other lengths and sizes. Subject to special inquiry.
Straightness. Maximum deviation from straightness: 1% of length.
Maximum diameter. Covers all tolerances, including ovalness.

TABLE 5—PYROMETER AND FURNACE TUBES (OPEN, OR CLOSED ONE END) IN ALUMINOUS PORCELAIN AND MULLITE.

Bore mm	Tolerance Limits %	Nominal Wall mm	Maximum Ext. Dia. mm
5·0	±10	1·5	9·0
5·75	±10	1·5	9·8
6·25	±10	1·85	11·2
8·0	±8	2·0	13·5
10·0	±8	2·25	16·0
12·5	±6	2·5	19·0
15·5	±6	2·75	22·5
19·5	±6	3·0	27·5
22·5	±6	3·0	31·0
25·5	±5	3·25	33·5
28·5	±5	3·5	37·5
32·0	±5	3·5	40·5
38·0	±5	4·0	48·0
45·0	±5	4·5	56·5
50·0	±5	4·5	62·0
55·0	±5	5·0	68·0
65·0	±5	5·0	78·5

Lengths. Normally supplied from 300 mm in 75 mm steps up to 1,350 mm for bores up to 32 mm dia. and up to 900 mm for the larger bores.
Other lengths and sizes. Subject to special inquiry.
Straightness. Maxium deviation from straightness, ½ per cent. of the length.
Maximum diameter. Covers all tolerances including ovalness.

It will be observed that tolerances have not been specified with regard to length. This is because the tubes are cut after manufacture, and the accuracy is usually more than sufficient.

Two main considerations usually determine other geometrical requirements:

(1) The user needs a tube of such bore that a given object will pass through it, or can be manipulated within it.
(2) Parts or all of the exterior must pass through one or more cylindrical apertures.

These requirements may determine not only the nominal bore and outer diameter, but the straightness and circularity. It may be noted that whereas variations in average bores and external diameters are mainly determined by the technique of producing and firing the tubes, deviations from straightness and circularity can occur in tubes of correct average dimensions, and it is not easy to ensure that the deviations are always small enough to be unimportant. If all tubes were straight and circular, the specifications of average bores and external diameters would involve the user in no difficulty, for he would merely have to be guided by his known requirements and the tolerances stated by the manufacturers. Unfortunately, variations in straightness and circularity can be infinite in their diversity, although appreciable variations of this nature more usually apply only to recrystallised alumina. In such cases they can be simply expressed only by arbitrary selection which may not correspond with the precise needs of the user. For example, lack of straightness is expressed in the Tables as the greatest gap between the tube and a plane on which it is rolled, divided by the length of the tube, this ratio being expressed as a percentage. This simple and convenient criterion has been used for all tubes except those designed as insulators for thermocouples. Reference to Tables 2 and 3 shows that in the case of an insulator, whether of circular or of oval section, there has been specified the bore of a tube gauge which can contain the whole insulator. It should be noted that the use of short insulating tubes sometimes enables a narrower outer tube to be used than would otherwise be possible. The minimum bores of both single and twin bore insulators are also specified as indications of the sizes of wire which may be used.

General

It is believed that the dimensional system adopted will usually reduce the task of choosing suitable tubes to little more than reading the standard Tables. Thus, for tubes other than insulators, the maximum external diameter is an indication of the least diameter of a short cylindrical hole through which the tube could be expected to pass. If to this diameter, we add the maximum deviation from straightness, calculated from the actual length of the tube, we obtain the least diameter of a true cylindrical tube which can be expected with certainty to contain completely the listed tube. As an illustration, let us consider a tube 600 mm. long, and in other respects as stated in the first entry in Table 4 for pyrometric and furnace tubes in recrystallised alumina. The maximum deviation from straightness is less than 1 per cent. of 600 mm., that is, less than 6 mm. The maximum external diameter is 9 mm., so that the smallest cylindrical enclosure which we could be certain would contain the *whole* tube, would have a diameter slightly in excess of 15 mm. It will be appreciated that the occasions when this is essential are relatively few. The bore is 5·0 mm. ± 10 per cent., so that the smallest possible bore is 4·5 mm. Hence, the smallest twin-bore insulators listed, even in 75-mm. lengths, would generally fit the tube, although there might be cases in which a larger outer tube would be needed. This is because, although the list shows apparently ½ mm. clearance for the longest twin-bore insulator, clearance may be lost by lack of straightness of the outer tube. This example illustrates both the utility and the limitations of the system. The limitations are not serious, and are outweighed by the accompanying simplicity.

Special lengths and sections, and tolerances smaller than those listed, will be subject to special quotations, which normally will involve higher prices and longer times of delivery than those of standard ware. It is in the interest of both consumers and manufacturers that such requirements be kept to a minimum. Quite a small alteration in existing apparatus will often enable standard ware to be used, and when new apparatus is designed, adjustments should be provided in accordance with the known tolerances. Further, ease of manipulation is often more important than first cost, for both time and material may be wasted when objects are manipulated within tubes which fit too closely.

Conditions of Use

The choice of a refractory tube involves consideration of the nature of the refractory, and of the conditions of use. The manufacturers will gladly advise on these products if given adequate information. Some users may have special problems, but most cases are covered by answers to the following questions:

(1) What is the *true* maximum temperature expected?
(2) What will be the period of the firing cycle, and the approximate distribution of temperature along the tube?
(3) In the case of a horizontal tube, what will be the length of the hot section, and how will it be supported?
(4) What solids, liquids, and gases, will be in contact with the hottest parts of the tube, both inside and outside?
(5) What will be the pressure of such gases? In the case of a vacuum, will continuous pumping be permitted?
(6) In the case of an electric resistance furnace, will the current be direct or alternating? What type of metal will be used for the winding?

TARIFF PROTECTION

A REUTER report states that delegates to the annual convention of the International Brotherhood of Operative Potters' meeting at Atlantic City., U.S.A., recently passed a resolution in favour of higher tariffs to protect the American dinnerware industry from the "menace" of imported dishes. It was stated that recently many members of the union have been on short time because of a slump in the dinnerware section of the pottery industry.

Sand Industry Wage Increase.—About 10,000 men in the sand and ballast industry are to get more pay under an Industrial Court award announced recently. Labourers and "C" class drivers will get 1½d. an hour more, and there will be a proportionate increase in watchmen's rates. The men had claimed 3d. an hour increase. The award was effective from the beginning of the first full pay period after August 6th.

Brickmaking Under Difficulties

BUILDING native houses in remote parts of Africa is a job that demands ingenuity and the knack of making the best use of local materials.

This has been discovered by teams working for the British firm of John Laing & Son Ltd., who are the only firm of contractors in Northern Rhodesia to have built African houses away from the railway line. The only other houses built for Africans in this way are being put up by the Government with direct labour.

Brick-making, for instance, has all to be done locally. At one site, Kasama, the nearest rail depot was 459 miles away. Here a suitable spot had to be found for the hand-moulding of bricks, which were made from the ant-hills. Averaging 20 ft. in height, the latter are built by termites and are a

(Top, right). Selected earth was trampled underfoot and mixed with water to form the pug. (Above). After being turned out of the moulds the bricks were sun-dried for three days

feature of the African bush. One hill will contain about 600 cu. yd. of soil.

For this Kasama contract African labour, working in gangs, moulded 1,800 bricks a day. Some eight months were spent in making 2½ million bricks. Burning was done by timber cut from the surrounding bush. To transport the timber to a kiln a road six miles in length had to be cut across virgin country. To make this road possible 20,000 trees had to be cut down and timber bridges were thrown across two rivers, the largest having a span of 54 ft.

side, thus giving a fairly even distribution of heat. All crevices were filled up by plastering the outside of the kiln with mud.

Here, the team had to go as far as ten miles into the bush to establish a wood-felling camp, which would provide a continuous supply of fuel. This was worked by Africans, who made themselves a village of grass huts.

During its seven days burning each kiln used some 120 cords of timber and to keep the fires going wood cutting was often a seven-day-a week job.

In spite of all difficulties 450 houses

After drying, the bricks were stacked into a kiln to hold about 150,000 bricks, which incorporated seven or eight firing chambers on each side

A similar story has been told from another site at Fort Jameson where bricks were made of selected earth. This was trampled underfoot and mixed with water to form the pug. To shape the bricks moulds were made in the carpenters' shop on the site. Into these the pug was compressed. After being turned out of the moulds the raw bricks were sun-dried for three days, a different face being turned to the sun each day. They were then stacked into a kiln to hold about 150,000 bricks which incorporated seven or eight firing chambers on each

are being built at Fort Jameson, while 200 houses have been built at Kasama, 133 at Abercorn, 30 at Lunzuwa and 168 at Chilanga for the cement company there. The latter was the only site on the railway line.

Mr. H. Hewitt.—Mr. Harold Hewitt, general secretary of the National Society of Pottery Workers, is to be a member of the T.U.C. delegation of three at the Asian Conference, to be held at Tokio under the auspices of the International Labour Office. The delegation will leave London on 11th September.

New Equipment for Handling Bulk Cement

THE time and heavy labour costs involved in handling cement in bags would appear to make attractive a new system of handling cement in bulk, recently demonstrated to a trade and press audience in York.

This new system employs a silo of resin bonded laminated wood construction which provides ideal weatherproof storage conditions for the cement. It is easily placed in position adjacent to the mixer can, with its associated dispenser, thus reducing handling to a minimum, eliminating waste from split bags and spilled cement, and working conditions are almost entirely free from cement dust.

The size and construction of the Portasilo, as the container is known, makes it possible for it to be moved from site to site as the work progresses, and it is claimed by the designers that a saving can be effected on any site using over 1 ton of cement per week.

The smallest sized Portasilo has a capacity of 10 tons of cement, is 16 ft. 4 in. in height with an overall width of 6 ft. 5 in. Its weight is 10 cwt. without discharging mechanism.

The silo is provided with tubular handrails by means of which it can be manhandled about the site by a concreting gang or can be transported from site to site by a flat-bed lorry. Incorporated in the design is a keel which, when the Portasilo is erected, provides a step-ladder for inspection of the contents and which, when the silo is being moved, provides a base and the necessary rigidity to prevent damage to the structure.

Dispensing mechanism, called the Pullwey Mechanical Cement Man, consists of a hopper mounted upon rails fixed to the Portasilo. The hopper is placed in position under the discharge valve and when the measured quantity of cement has been released from the silo the weight automatically closes the discharge valve; the charged hopper can then be withdrawn and pulled along the rails to position over the mixer hopper where it is discharged by raising the handle which has previously served to move it into and out of position under the silo valve.

The Portasilo, once in position on the site, is served with cement by means of

Silo being filled from cement tanker, whilst cement gang continue mixing

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a cement tanker, and considerable development work has gone into the production of this specialised vehicle which, as shown in our illustration, consists of two spheres mounted upon a lorry chassis—the lorry is equipped with a specialised air-compressor which expels the cement, previously loaded into the spheres by gravity, passing it into the Portasilo via a hose connection, which terminates at the head of the silo and thus ensures that the cement is used in order of delivery, the discharge valve of the silo being placed at the bottom of the structure.

With this equipment, which has been developed over a considerable period by the well-known northern firm of civil engineers and building contractors, F. Sheppard and Son Ltd., of York, it will be seen that very considerable savings can be effected by the elimination of the heavy labour costs involved in handling cement in bags—in addition to the advantages accruing from accurate dispensing, clean site conditions, etc.

The Portasilo is marketed by the Portasilo Co., of Blue Bridge Lane, York, whilst the cement tanker is being fabricated with Noral materials by the London Aluminium Co., of Witton, Birmingham. A Bedford 7-ton chassis is used for the cement tanker because its weight is low for its payload capacity. The containers, being made of aluminium, makes it possible for the unladen weight of the vehicle to come within the 30 m.p.h. class.

Pottery and Glass Trades' Benevolent Institution.—Colonel G. A. Wade, chairman of the Wade Group of Potteries, has been re-elected chairman for the fourth year, of the Board of Management of the Pottery and Glass Trades' Benevolent Institution. Mr. Felton Wreford, London Manager of Josiah Wedgwood and Sons Ltd., has been re-elected deputy chairman. The Hon. Josiah Wedgwood was appointed Trustee in place of the late Mr. H. H. D. Minton-Senhouse. Retiring members of the Board, Mr. R. J. Cannon, Mr. F. J. Hadley and Mr. G. W. Stuart, were re-elected.

Colonel H. E. Emery.—We regret to announce the death of Colonel H. E. Emery, following an illness. Colonel Emery was, until July last year, general manager of Staffordshire Potteries Ltd., Meir, one of the Keelestreet Group, from its formation in March, 1951.

Depreciation and Maintenance of Pottery Manufacturing Equipment

8—Control of Buying Department

by S. HOWARD WITHEY, F.Comm.A., etc.

FOR the purpose of securing initial allowances, the items of capital expenditure can usually be readily collected in the form of monthly or other convenient totals for ledger-posting by using a pattern of bought journal which has been provided by the printer with a number of columns for the different classes of manufacturing equipment, the total amount rendered on each invoice being credited to the supplier's personal account kept in the purchases ledger and the periodical totals debited to the specific asset accounts opened in the private or impersonal ledger. At the end of the bought journal a few pages should be reserved for recording the value of returns outwards, including all allowances made by suppliers in lieu of actual returns, the individual items corresponding with those shown on the credit notes received, and apart from the entries made in the ordinary financial books it is advisable to maintain a number of equipment and stock accounts, these being preferably grouped under the most suitable headings.

Under the existing conditions, the purchase of kilns, wheels, drying stoves, conveyors, tanks and trucks is governed to a large extent by prevailing market prices, and before placing an order for the supply of capital equipment some pottery manufacturers insist on obtaining several quotations, the final choice usually depending on the state of the order book and the special local circumstances. In this connection, there are indications that the need for liquid capital and ready money to meet management expenses and overhead charges is compelling many buyers of capital goods to limit their purchases, and it should never be forgotten that a small turnover will usually absorb much more capital, relatively speaking, than will a large turnover; consequently, unless there are urgent reasons for adopting such a course the number of units of equipment needed to maintain output should not be allowed to dwindle below a definite and predetermined minimum.

Orders for the supply of blungers and machines are sometimes made out on printed forms giving the date, the number of the order and a full description, and if possible these forms should be signed by the proprietor, one of the partners, or by a director, as the case may be. Unless alternative descriptions are specifically authorised it is always advisable to make clear to suppliers of manufacturing equipment that any deviation from the particulars and specifications enumerated on the order forms will be entirely at their own risk, and when dealing with an agent for the first time the terms of business, including price, date of delivery and method of payment, etc., should be confirmed to prevent any inconvenient misunderstanding. By using a duplicate book containing thin tissue leaves, and making out the orders on the carbon-copy principle, the manager or foreman will be able to refer to any details when required; if more than one authentic copy is needed for departmental or other purposes a manifold order book may be more convenient.

Directly the number of units of loose plant under a particular heading reaches a predetermined minimum, it is a good plan to make a note in a

special book, this being provided with columns or sections for the insertion of such details as the date, a description of the plant required, the name of the manager or department and the number of units to be ordered. For use in the office a separate section should be provided on the right-hand side of each page of the book, consisting of columns for recording the date and number of each order, the name and address of the supplier or buying agent, the number of units ordered and received and the page on which the corresponding entry appears in the inwards book kept in the receiving department. Although there is no standard pattern of plant order book, the following is a useful form of ruling capable of ready modification to satisfy any requirement:—

If the invoices and other debiting documents go direct to the purchasing department they should be stamped by means of a rubber stamp or other suitable impression to show the number and date and the initials of the assistants who have taken part in the routine work, such as verifying the condition of the plant, checking the prices and discounts, passing for payment, and the folio of the purchases journal. To enable separate asset accounts to be compiled, the plant can be grouped under appropriate headings by using record cards showing, on the debit side, the dates on which the various consignments were actually received and the names of the senders, and on the credit side the dates on which the units were issued to the drying room, slip house, decorating

POTTERY PLANT ORDER BOOK

(Left-hand Side)

Date	*Ref.*	*Description of Plant Required*	*Manager or Department*	*Number of Units Required*	*Order Authorised by*	*Remarks*

(Right-hand Side)

Date	*Order No.*	*Description of Plant Ordered*	*Supplier or Buying Agent*	*Number of Units Ordered*	*Condition On Arrival*	*Inwards Book Folio*

department or to other specific processes. Each entry made on the received side of a plant card should give the order number as originally specified, and against each entry on the issued side should be inserted the number of the official requisition, and by keeping such records up-to-date it is often possible to determine the value of the plant in use at any time.

Many pottery manufacturers now avoid serious disturbance due to a closing down by relying entirely on the accuracy of their inventory records, although for the purpose of arriving at a reliable figure for inclusion on the balance sheet a physical stocktaking is advisable.

The process of stocktaking is always somewhat tedious, but a good deal depends on the accuracy of this work and in order to ensure the best results the details should first be set down on sheets and then classified to give the separate totals required for entry in the books and for incorporation in the periodical trading or profit and loss account. The customary basis for valuation is the net invoiced cost price, although in those cases where the market price of any description has fallen below the actual cost the items are sometimes priced out at the prevailing wholesale prices. When ascertaining the amount of stock and the value of the work in progress to be recorded on the credit side of the manufacturing account it is important that no assets such as plant, furniture, fixtures, fittings or loose tools—the value of which is shown in separate ledger accounts—should be included, as this would have the effect of inflating both the credit side of the final account and the assets side of the balance sheet. Units of plant or materials received but not yet entered in the purchases journal at the time of stocktaking by reason of the absence of invoices should also be excluded from the inventory.

AMERICAN CERAMIC SOCIETY

THE following are abstracts of papers appearing in the May, 1953 issue of the *Journal of the American Ceramic Society:*

"Subsolidus Reactions in Oxide Systems in the Presence of Water at High Pressures," by E. F. Osborne, of the School of Mineral Industries, the Pennsylvania State College, State College, Pennsylvania:

Phase equilibrium studies at subsolidus temperatures, made in the presence of an aqueous phase at high pressures, are briefly reviewed for the systems eucryptic-silica, Al_2O_3-Ga_2O_3, $MgAl_2O_4$-Al_2O_3, and TiO_2. Low-temperature equilibrium relations have been largely clarified for the first three systems because of the greatly increased reaction rate in the presence of a fluid phase. For the system TiO_2, however, hydrothermal techniques appear to be inadequate for the determination of stability relations. The hydrothermal syntheses of forsterite at 500° to 700° C. from magnesia and silica or from dolomite and silica, and of mullite at 500° C. from clay minerals, are mentioned as reactions of possible industrial significance. A further acceleration of reaction rate at low or moderate temperatures is being achieved by grinding at elevated temperatures and pressures.

"Metallographic Examination of Ceramic-Metal Seals," by A. G. Pincus of the General Electric Research Laboratory, Schenectady, New York:

The making of taper sections of ceramic-to-metal seals is described. Their usefulness is illustrated by applications to (1) research into adherence mechanisms and (2) production trouble shooting. The laboriousness and pitfalls in taper-section preparation and interpretation are stressed. In spite of them the technique has been the most productive approach to understanding and controlling the seal art.

"Note on Modulus of Rupture of Cylindrical Ceramic Rods when Tested on a Short Span," by Lowell H. Milligan, of the Research and Development Department, Norton Co., Worcester, Massachusetts:

It is known that for rectangular bars corrections are necessary for the simple modulus of rupture formula to obtain true cross-bending strengths when the ratio of span to bar depth is less than about 10:1. The experiments described in this note develop empirical data on this subject for cylindrical rods of low span-to-diameter ratios.

"Study of Some Binary Silicate Glasses by Means of Reflection in Infra-red," by I. Simon and H. O. McMahon, of Arthur D. Little Incorporated, Cambridge, Massachusetts:

The reflection method provides means of studying the 10-micron infra-red region that contains the fundamental vibration of the silica lattice. Structural

changes produced by introduction of various amounts of alkali or alkaline-earth network modifiers can be conveniently followed. A series of soda-silica glasses was studied in an interval of 0 to 46 mole; other binary glasses containing Li, K, Ca, Sr, and Ba oxides also were investigated.

"A Theory of Cation Exchange Reactions with Clay Minerals," by Ivan B. Cutler and Melvin A. Cook of the College of Mines and Mineral Industries, University of Utah, Salt Lake City, Utah:

A consideration of the possible cation exchange reactions with clay-mineral surfaces in aqueous media leads to an equilibrium expression with which it is possible to obtain a good correlation of data in the literature. Free-energy considerations based on approximate equilibrium constants also support the theory. The ionic strength contribution of the various clay minerals is shown to be large enough to account for displacement of curves due to differences in clay-water concentration.

"Effect of Molten Aluminium on Alumina-Silica Refractories," by K. J. Brondyke of the Process Metallurgy Division, Aluminium Research Laboratories, Aluminium Co. of America, New Kensington, Pennsylvania:

All commercial alumina-silica refractories were found to be wetted and subsequently penetrated on exposure to molten aluminium. Penetration and silicon pickup by the aluminium was independent of porosity, grade of refractory, and source of the refractory material. The rate of penetration was governed by the diffusion of aluminium and silicon. The adherence of build-up to alumina-silica refractories is related to the silica content of the refractories.

EDINBURGH VENTURE

THE Castle Wynd Potteries, of South Castle Wynd, Edinburgh, is a venture in the Edinburgh tradition, using local clay and now, after three years of work, successfully established. The small pottery stands below the ramparts of Edinburgh Castle and uses buildings of considerable age as pottery and showroom.

Castle Wynd Potteries was established by James G. Crawford, former Edinburgh Art College student, in 1950. He has specialised on a wide range of earthenware using West Calder clay. Miss Mary M. Mackay joined the Pottery over a year ago, to specialise on figure work, and has since created a substantial following for her pieces.

As is inevitable on such ventures, the initial work has been hard and progress relatively slow. The first year was spent in accumulating a sufficient stock to float the venture and work thereafter has been aimed at maintaining the flow in the face of a considerable demand—which rises to peak during the holiday and tourist months.

A particularly interesting aspect of this venture is that it has been accompanied by a sound sense of promotion. The policy has been to take traditional themes and to vary these, sometimes in miniature, and to promote a specific theme or type each season. A year ago Crawford sponsored a revival of the Bellarmine, taking this traditional shape and reducing it in size. This year the Potteries are featuring the "Saut Bucket." Explaining this, the Potteries say that the Saut (Salt) Bucket was used in Scotland to hold meat or fish for pickling against winter use in the days before canned foods. Original Saut Buckets were from 2 to 3 gal. in size and were filled with brine, into which the housewife put the meat she wished to preserve. This use diminished and the dish was used to hold cooking salt, standing always beside the cooking stove. In their own version, Castle Wynd have taken the larger shape and reduced it to cruet size, for use singly or as part of a set. This is an excellent example of adaptation of a traditional type to present use—with a story which can be used to help sell the miniature.

Miss Mackay has specialised in figure work and has brought an inventive ability to this field which is most attractive. Her modern version of the old "Wally Dougs" is equally a revival of a tradition, and a much more individualistic expression of the theme than was possible from the old Scottish potteries which mass-produced their chimney dogs. She has "Pirly Pigs" and "Dabbities," again revivals in modern tempo of older mass-produced Scottish themes, as well as a host of animals and figures and freehand renderings which are in keeping with the present interest in such work.

An interesting feature of her work is that it is gay, humorous, even cheeky in its rendering, her "Wally Dougs" more like French poodles than the staid, sad spaniels which used to decorate the mantelpieces.

THE FLOW OF CLAY PASTES

by

M. Y. BAKR and A. ISKANDER

(Faculty of Engineering, Alexandria University, Egypt)

Some experiments on the flow of clay pastes are performed with a view to explain the effect of the ionic atmosphere on the variation of the viscosity with the rate of shear. The yield value was found to depend on the strength of the atmosphere. Pastes of clays in alcohol seem to have a viscosity independent of the rate of shear.

INTRODUCTION

IT is known that the flow characteristic of a concentrated paste is usually represented as Fig. 1, in which the flow begins after a critical stress has been exceeded and then it will be proportional to the excess of rate of shear. The straight portion does not pass through the origin and therefore the coefficient of viscosity is not constant but varies with the rate of shear. The paste can be classified therefore as a

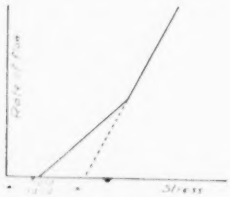

Fig. 1

non-Newtonian fluid or system. Different physical and chemical factors are responsible for the shape of the flow curve. One of the most important factors, in the opinion of the authors, is the strength of the ionic atmosphere surrounding the clay particle. It is the purpose of this work to try to explain the rôle in which the ionic atmosphere affects the value of the apparent viscosity. The study of the flow of some Egyptian clays had confirmed our point of view.

The Effect of the Ionic Atmosphere

It is known that when the clay particle is in suspension, in water, it is surrounded by a diffuse ionic atmosphere, the nature and extent of which depends on the cation associated with it. The anions are located on the surface of the particles and a water envelope or liosphere is associated with the particle, the size of which is controlled by the cation present. The particle will thus behave as a giant ion in a solution in the sense that it is a charged by one kind of electricity and is surrounded by an ionic atmosphere of contra ion.

As long as the ionic atmosphere is stationary, i.e., it is not disturbed or exposed to a shearing force tending to move the particle with respect to the solvent, it has a spherical symmetry. This symmetry will be disturbed however, when the particle is made to move. The asymmetry of the ionic atmosphere will result in a retardation of the moving particle, thus contributing to an increase in the viscous forces. If the particle is made to move very quickly it would be virtually free from an oppositely charged ion atmosphere, since there is never time for it to build up. Thus we may see that the retarding effect of the asymmetry in the ionic atmosphere decreases as the velocity of shear increases. The viscosity of the system should be expected, therefore, to decrease with the rate of shear and tend to a limiting value at an infinite rate of shear.

This should not be considered as the only cause of the anomaly of the viscosity of clay pastes. It can only be looked at as the factor governing the value of the activation energy required to shift the particle from its normal

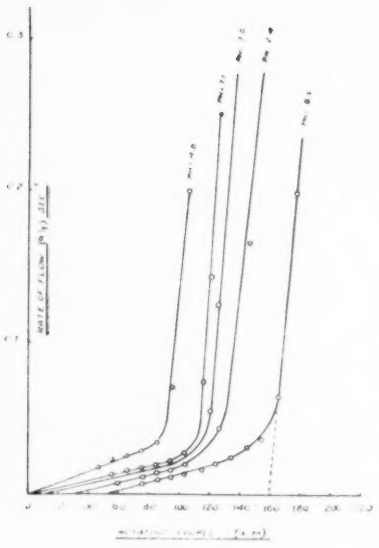

Fig 2

position. On the assumption of the existence of an interaction between this activation energy and the elastic strain energy, de Bruyne[1] obtained a generalised expression for the relaxation between velocity gradient and shearing stress. It is shown that the derived quotation can account for the anomalous characteristics of amorphous materials. According to our explanation, the dependence of the viscosity of a clay paste on the rate of shear should be most marked under such conditions that the influence of the interionic forces resulting from the existence of an ionic atmosphere is abnormally large. This might be the case when the particles are highly electrified.

It may be mentioned here that Eirich and his collaborators[2] found no anomaly in the flow of a suspension of electrically neutral particles dispersed in a mixture of paraffin and tetrachlorethane. Also no anomaly was found by one of the authors[3] in the flow of emulsions of paraffin in glycerine. The emulsifier used was sodium oleate which is known to have very weak dissociation in the external phase; the glycerine, and hence the ionic atmosphere associated with the paraffin particles was believed to be very weak.

Now, the electric strength of the ionic atmosphere surrounding the particle can be varied by varying the *p*H value of the paste. If the strength of the atmosphere was responsible for the variation of the viscosity, the flow characteristics should vary with the *p*H value.

EXPERIMENTAL

The flow curves of some Egyptian clays, prepared in pastes of different *p*H values, were studied by means of Searle's coaxial cylinder viscometer. The inner cylinder is rotated by a couple produced by two masses each of mass M grams, supported by threads which are wound round a drum on the axle and pass over a ball bearing pulley. The rate of flow, as well as the rate of shear is proportional to $1/3$; where it is the time of a complete revolution. The rotating couple is obviously proportional to the mass M, whereas the apparent viscosity of the fluid contained between the cylinders is proportional to the product Mt.

The *p*H value was varied by means of very minute traces of sulphuric acid or sodium hydroxide, which is added to distilled water before preparation of the paste. The *p*H value of the paste itself is measured by means of a glass electrode *p*H electrometer.

Fig. 2 shows a typical family of curves for a red Aswan clay. The Bingham[4] yield value is measured by the intercept of the stress axis obtained by extrapolating the final

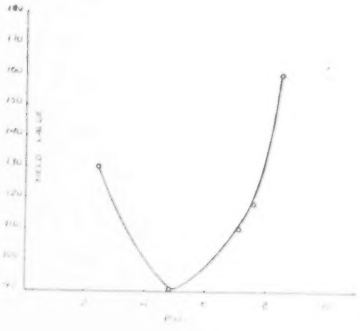

Fig. 3

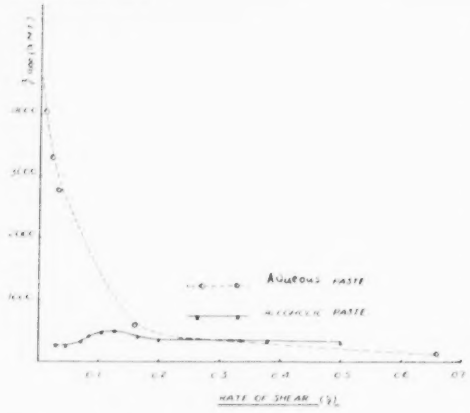

Fig. 4

straight portion of the curve. It is apparent from the figure that both the yield value and the apparent viscosity of the paste is highly affected by its *p*H value. On the other hand the mobility of the paste, as measured by the slope of the final straight portion seems to be practically independent of the *p*H value.

The variation of the yield value with the *p*H value for this kind of clay is represented in Fig. 3, which shows that the yield value seems to be minimum at the isoelectric point when the ionic atmosphere is very weak. On both sides of the isoelectric point, the yield value increases owing to the increase of the electric strength of the ionic atmosphere.

Pastes of clays in alcohol

Pastes of clay in alcohol were prepared in the usual way using absolute alcohol instead of water. This was with a view to reduce the opportunity for the clay particle to be surrounded with an ionic atmosphere. The flow curves of these alcoholic pastes were compared with those of aqueous pastes having the same proportions of clay to solvent. Fig. 4 shows typical results for the dependence of the apparent viscosity on the rate of shear for two pastes, one aqueous and the other alcoholic. It is to be mentioned that the *p*H value of the aqueous paste was adjusted to be the same as that of the alcoholic one.

Fig. 4 shows clearly that the viscosity of the alcoholic paste seems to be practically constant and independent of the rate of shear, except at the beginning where its curve shows slight dilatency. At the same time the viscosity of the aqueous paste appears to decrease as the rate of shear increases.

The slight dilatency of the alcoholic paste, observed at first may be explained on the lines similar to those followed by Macey[5] for the explanation of the dilatency of starch solutions. We can assume that alcohol had strongly dehydrated the clay particles and left them crumble and owing to the lack of a charge around them, they might collect in groups of non-uniform structure. The application of a shearing stress will, therefore, tend to unroll these groups and in doing so they increase the resistance to flow, in other words the apparent viscosity increases with the rate of shear.

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SPRAY GUN SELECTION

We have received from The Aerograph Co. Ltd., Lower Sydenham, London, S.E.26, a spray gun selection guide.

A representative list of industries, trades and finished products shows the types of guns generally used and under the heading of each spray gun in the guide can be found the air cap and fluid tip sizes together with the classes of work for which they are used, the width of the spray pattern, the method of feed, the spraying pressure recommended and the actual air consumption.

The company state that the guide is based on average conditions, but point out that their technical department is available to deal with all finishing problems—this is of particular value where special circumstances prevail.

RESIN-BONDED GLASS LAMINATES

by

R. H. WARRING

MOULDED laminates fabricated from woven glass cloth or glass mats have by now established themselves as a suitable alternative to steel or light alloy sheeting in a wide variety of applications. These materials, known generally as "glass plastics," possess high tensile strength and impact resistance, are relatively easy to form or mould and completely proof against most normal forms of corrosion. Initial experiments with materials of this kind led to the production of small boat hulls in fibreglass laminates, where the material is essentially employed in a stressed condition, and for large fairings, ducts, etc., on aircraft, where working stresses were low.

The stress-carrying properties of the material showed up so well that glass plastic boat hull construction has become almost an accepted standard, not necessarily limited in scope to small sizes. However, the immediate field which appears to offer widespread possibilities for development is in the construction of automobile bodies moulded, "as one" from woven glass cloth laminates. Already such technique has passed through the experimental stage in the United States and at least one current production model does, indeed, feature a glass plastic body. One American firm with a direct interest in the British automobile industry has similar ideas for an Anglo-American car to be manufactured in this country.

Considered simply as a structural material, resin-bonded glass laminates are expensive. However, if the overall production costs are compared the fact that large and relatively complicated shapes can be laminated with the use of only low-cost dies the picture becomes more attractive. This is particularly true where a small number only may be required, off a large aircraft fairing, for example. Fabrication from sheet metal (probably in the form of a number of metal pressings or stampings, subsequently joined) may require a considerable outlay in tools and dies. For something less than one-tenth the die cost, hand wrapping may produce a comparable article in glass plastic, using nothing more elaborate than a plaster die. The glass laminate, too, would be in one piece.

As far as mechanical properties are concerned, glass laminates compare very favourably with the normal sheet metals used for structural purposes. Their tensile or compressive strength is somewhat lower than comparable steel or light alloy sheet, but flexural strength is higher. As a result, glass laminates, in general, tend to have a higher fatigue strength and are capable of absorbing impact loads which would seriously damage or ruin sheet metal used in similar circumstances.

If a finished glass laminate is damaged, too, a permanent and fully effective repair can be made by hand methods with the minimum of trouble. The damaged area is simply filled in or reinforced with new glass mats or glass cloth impregnated with the appropriate resin binder and either cured or left to set. Hand methods may be used throughout, if necessary.

A further comparison between glass plastics and metals might be drawn with regard to their mechanical working properties. Finished fabricated glass plastics can, in fact, be sawn, planed, shaped, punched, drilled, tapped, etc., similar to metals. The fabricated laminate is extremely tough and abrasive and so requires the use of metal-working

TABLE 1.—MECHANICAL PROPERTIES OF TYPICAL GLASS-RESIN COMBINATIONS

Glass-Resin Combination		Specific gravity	Tensile strength p.s.i.	Compressive strength p.s.i.	Flexural strength p.s.i.	Shear strength p.s.i.	Bearing strength p.s.i.	Impact strength (ft.-lb./in.)	Moisture Absorption % 24 hrs.
Glass (% vol.)	Resin (% weight)								
55	30								
Parallel fibres		1·90	120,000	70,000	150,000	—	—	70	0·15
50	34								
Parallel laminates		1·85	77,000	70,000	115,000	—	—	55	0·25
45	38								
Fabric		1·75	40,000	35,000	60,000	19,000	42,000	25	0·30
25	60								
Mat or preform		1·55	24,000	25,000	32,000	17,000	39,000	25	0·40
0	100								
Pure polyester resin		1·05-1·30	7,000-6,000	14,000-21,000	12,000-13,000	—	—	0·4	0·04

TABLE 2.—MECHANICAL PROPERTIES OF TYPICAL "STRUCTURAL" METALS

Metal	Specific gravity	Tensile strength tons/sq. in.	Yield strength tons/sq. in.	Elastic modulus E	Bearing strength tons/sq. in.	Shear strength tons/sq. in.	Range strength tons/sq. in.	Corrosion resistance
Aluminium sheet	2·70	5-10	2-9*	$10·0 \times 10^6$	5-10	4·5-6·5	2·5-5	Excellent
Al-alloy sheet	2·80	10-30	5-25*	$10·0 \times 10^6$	10-30	—	—	V. good
Brass—Soft	8·6	20	7	15×10^6	—	15	—	Fair
—Hard	8·6	40	26		—	—	—	Fair
Copper—Soft	8·94	20	5	$17·5 \times 10^6$	—	5	—	Good
—Hard	8·94	30	12		—	12	—	Good
Cast iron	7·7	10	—	12×10^6	—	17	—	Poor
Structural steel	7·8	32	16	30×10^6	—	22	—	Poor

*0·1 % proof stress.

tools of the carbide type, for preference. Woodworking tools, carbon steel tools, or even high-speed steel tools are not satisfactory for finishing work.

Laminated glass plastics also offer the possibility of making satisfactory bonded joints between the laminate and other materials, e.g. metals. This could, in fact, be considered as the equivalent of "welding" such joints. Commonly, however, riveting or bolting in place is preferred. In general, especially with edge joints, holes for rivets or bolts are reinforced or built up to reduce any tendency for the material to "craze."

Typical mechanical properties of various glass and resin combinations are summarised in Table I, together with some appropriate data on sheet metal used for similar applications in Table 2. These data applicable to glass laminates are from an American source and supplied by Messrs. Fibreglass, Ltd., of St. Helens, Lancs.

This company does, in fact, produce two types of glass mat reinforcements and also continuous filament fibreglass thread. Woven glass cloths are manufactured by separate concerns. Both mats and woven cloth are used in the preparation of laminates, and also chopped fibres. There are, in fact, some six distinct methods of moulding or preparing the final laminate. Some techniques involved the use of high or low pressures, with or without heat treatment. Others require pressures of the order of only a few ounces per square foot to hold the laminate to the shape of the form or die during subsequent curing or drying. The technique chosen depends very largely on the type and purpose of the article being moulded.

For cheap laminates of relatively large size, and where the numbers required are limited, hand laying of the glass mats or cloth may be used, the appropriate resin being sprayed on during the laying process, or resin-impregnated mats or cloth employed. The laminate is then cured without the application of pressure. A similar, but slightly more elaborate method, utilises the same method of laying up, but this time in a female mould. A rubber bag is then laid in place and clamped down and inflated, thus producing an even pressure of the order of 10 to 15 lb. per sq. in., forcing the resin-impregnated glass against the inside of the mould. A further alternative is to lay up the glass mats or cloth on a male mould, placing a female mould in position and sucking up resin into the glass matrix by means of a vacuum. The latter method produces a "finished" surface. With either of the other techniques, curing is generally followed by sanding, filling and painting. Fillers are not normally necessary in painting a laminate surface "as moulded."

An adaption of the Guerin method of forming sheet metals is sometimes employed for smaller laminates. In this a cast metal female mould is used and the resin-impregnated matrix impressed into the mould with a rubber forming head. This offers the possibility of producing accurate, smooth laminates with the minimum of tooling costs.

For both large and small subjects, moulding may be attempted from partly-cured laminates. The laminates are made as flat sheets, generally by a continuous roll process, cured in a hot air chamber and then cut to suitable stock sizes. If partial curing only is effected, these sheets can be moulded to final shape by pressing and then finally cured. Sheet laminates are produced in partially cured form for further press moulding, and in final cured form as corrugated and flat "insulated panelling" for building purposes.

Glass plastics are by no means limited in application to alternatives for sheet-metal panelling, fairings, bodies and hulls, etc. Many of the ordinary domestic articles produced from sheet metal by spinning, pressing or drawing, such as cylindrical tubs, baths and containers, trays, cover plates, etc., can and are being made from glass laminates with enhanced properties over their metal counterparts (high corrosion resistance and good impact resistance especially). For the production of large numbers of relatively small components, however, the flock preform process is generally used. The glass in this case is employed in the form of chopped fibres of up to 2 inches in length, rather than glass mats or cloth.

A "mould" of the shape required is fabricated in the form of a wire screen grid and mounted on a turntable in a vacuum chamber. The chopped glass fibres are loosely loaded into the centre of the mould which is then rotated and the vacuum chamber exhausted. The combination of low pressure and centrifugal force distributes the fibres uni-

formly over the surface of the wire screen mould. A small quantity of binder added during this operation dries out quickly so that the "pre-form" can be removed intact from the mould without losing its shape.

The pre-form is now transferred to a matched metal die mounted in a compression press and resin poured on. Pressure is then applied and the temperature raised to a suitable level to cure the moulding.

Pressures required are of the order of 150 lb. per sq. in. and curing temperatures up to 350° F.

Flock pre-forming has the advantage of being a relatively low-cost method for quantity production. Cost may be lowered by using fillers intimately mixed with the chopped fibres, which will also increase the opacity and "body" of the finished product. Chalk or china clay are the most common fillers used. The method is, however, more or less limited to relatively small parts of appreciably symmetrical form, although tanks with a capacity of 10 cubic feet are currently produced on a commercial basis by flock pre-forming in the United States. A suitable alternative method for non-symmetrical shapes for quantity production is normal compression moulding at pressures ranging from 25 lb. per sq. in. upwards and similar curing temperatures to the above.

Both temperature for curing and pressures for satisfactory forming are non-critical in the sense that the technique chosen can be suited to the facilities available. The larger hand-laid laminates previously mentioned, for example, may cure quite satisfactorily in warm sunlight or under the action of infra-red heaters (radiant heat). Low temperature ovens may be a more satisfactory solution for other applications. With the smaller items for quantity production it becomes advantageous to use higher pressures and higher curing temperatures to speed the production rate.

The overall picture is such as to emphasise that laminated glass plastics have a wide potential application in addition to the fields in which they are already establishing themselves, and also that the methods of fabrication employed can be most economical and adjustable to a considerable variety of needs, even to the virtual elimination of tool and die costs.

LIME SLUDGE FOR BRICK MAKING

THE production of bricks from lime sludge has been the subject of recent research at the Indian Central Glass and Ceramics Research Institute, Calcutta, and it is now claimed that good-quality sand-lime bricks can be manufactured from this by-product from acetylene gas works. Lime sludge is at present a waste product which is available in large quantities following the manufacture of acetylene from calcium carbide. An Indian acetylene gas factory will produce anything from 150 tons to 2,000 tons of it a month. The bricks are regarded as excellent for constructional purposes, being regular in size and composition. Normally resembling white sandstone in appearance they can be made in a variety of colours by incorporating suitable pigments.

The Central Glass and Ceramics Research Institute is one of a chain of laboratories set up as a first step in the systematic and planned attempt on the part of the Indian Government to apply science and technology to the growth and development of national industries.

British Ceramic Society.—Titles of the papers appearing in the July issue of the Transactions of the British Ceramic Society are as follows: "Vapour-Pressure Moisture Characteristics of Clays and their Relation to Plasticity and Bonding Properties," by B. Vassiliou and J. White. "A Study of Alumina Suspensions. II. Effect of Ageing on the p_H," by P. Howard and A. L. Roberts.

"The Fisholow Magazine."—We have received from the Material Handling Division of Fisher and Ludlow Ltd., the July issue of their house organ *The Fisholow Magazine*, an interesting and lively publication covering both the home and overseas activities of the company.

Sensitive Corrosion Measurements with an Interferometer

AN interferometer procedure is being used at the American National Bureau of Standards for studies of the corrosion resistance of such materials as optical glass, porcelain enamel, quartz and other natural and artificial silicates, and various metals. The method is believed to have value for comparing and predicting the chemical durability of various materials. Although interferometers have been widely used in science and industry for such problems as checking the accuracy of block gauges, measuring expansion, and checking optical "flats," they have apparently been used very little in previous studies of corrosion resistance. With the highly sensitive interferometer method, corrosion to a depth of as little as 1 or 2 ten-millionths of an inch can be detected on optically flat specimens.

Using an interferometer to measure the amount by which a corrosive solution has eaten away the surface of an optically flat specimen. This highly sensitive method of studying chemical durability permits detection of corrosion to a depth of as little as 1 or 2 ten-millionths of an inch

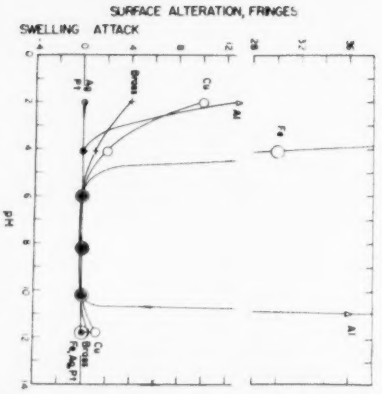
In the N.B.S. technique, devised by Robert G. Pike and Donald Hubbard of the Bureau's mineral products laboratories, specimens are ground and polished to optical flatness and then immersed to half their depth in the desired corrosive solution. After the desired length of time they are withdrawn, rinsed and dried, and covered with an optically flat piece of quartz. Using a conventional interferometric viewing apparatus of the Pulfrich type, and with an unfiltered helium lamp for illumination, the displacement of the optical interference fringes at the level-of-solution line of the specimen is observed.

As seen by the observer looking into the eyepiece of the instrument, these interference fringes are vertical parallel lines. If the uniform flatness of the specimen under study has not been impaired by the corrosive solution, these fringes are straight and continuous. However, if the previously-immersed part of the specimen surface has been sensibly attacked, each of the vertical fringes is shifted laterally at the point where it crosses the change-of-thickness line. If, as sometimes happens, the solution has caused swelling of the specimen, the lateral shift is in the opposite direction. A lateral shift equal to the space between two adjacent fringes corresponds to a dimensional change in the specimen amounting to one-half wavelength of light, or roughly 0·3 micron. (A micron is a millionth of a meter or about 40 millionths of an inch.) With careful use of the interferometer, changes in specimen thickness of as little as 0·003 micron can be detected.

Silicates studied by this procedure at N.B.S. were quartz, fused silica, opal, obsidian, flint, and pitchstone. Porcelain enamels studied were acid-resistant, class A; "glass-lined" tank; and acid-resistant, class D. Metals were cold-rolled steel, aluminium, copper, brass, silver and platinum. The corrosive agents ranged from concentrated sulphuric acid (H_2SO_4) to

5 per cent. sodium hydroxide (NaOH) solution. Exposure times were as short as 1 min. and as long as several weeks. Temperature in most cases was held at 80° C.

A number of interesting and sometimes unexpected results were obtained. Swelling of the immersed surface, rather than attack, was found in several cases. For instance, crystalline quartz showed definite swelling after two weeks at 80° C. in an acid solution (*p*H 4·1). Opal—like quartz, a form of silica (SiO_2)—showed swelling of nearly one fringe of light at *p*H 2, and continued at a similar level to about *p*H 8; between *p*H 8 and *p*H 11, however, the swelling changed rapidly to an attack of 3½ fringes. Although brass was attacked by strongly acid and strongly alkaline solutions, there was a slight indication of swelling in the more nearly neutral solutions. Such apparent swelling could perhaps be caused by the formation of a layer of insoluble salt having greater volume than the metal from which it was formed. Of the metals studied, only platinum showed no detectable dimensional change under the laboratory conditions. The three types of porcelain enamels studied varied widely in their chemical inertness as indicated by the test.

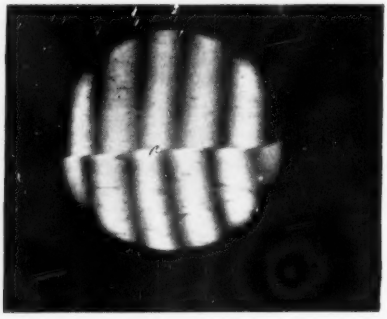


Results of measurements of the chemical durability of certain metals by the interferometric method. Data are for 6 hours' immersion at 80° C. in solutions of acidity or alkalinity. (Because of the rapid reaction of certain samples, immersions much shorter than 6 hours were sometimes necessary; such data have been extrapolated to the 6-hour basis.) Glass, porcelain enamel, and various silicates were similarly investigated

NOTE: *For further details, see "An Interferometer Procedure Applied to the Study of the Chemical Durability of Silicates, Enamels and Metals," by Robert G. Pike and Donald Hubbard, J. Research N.B.S. 50, 87 (Feb., 1953), N.B.S. Research Paper 2394. See also "Studies of the Chemical Durability of Glass by an Interferometer Method," by Donald Hubbard and Edgar H. Hamilton, J. Research N.B.S 27, 143 (1941), N.B.S. Research Paper 1409.*

Withdrawing an optically-flat specimen of glass from a beaker of corrosive solution in which the specimen has been immersed to half its depth. At the left are a number of other specimens whose chemical durability was studied by the sensitive interferometer method. Materials include silver, platinum, brass, porcelain enamel, and various natural and artificial silicates

Photo of a typical fringe pattern as seen through the eyepiece of the interferometer. Swelling of the lower half of the specimen—the half that was previously immersed in a corrosive solution—has caused displacement of the fringes (dark vertical bands) to the left. Here the shift amounts to about ½ fringe. (A shift of one fringe indicates a dimensional change in the specimen of about 12 millionths of an inch



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Crushing and Screening Plant

TO meet the ever-growing need for portability in crushing and screening plants, Keir and Cawder Ltd., Glasgow, Scotland, have now marketed their "Kompac" MK. I three-unit portable crushing and screening plant. This plant has been designed to suit road regulations and each unit has a braking system which can be operated from the towing truck.

Each unit is easy to handle, and can be drawn to the quarry face, jacked up in position, and put into operation in a short time. Where the plant will be operating in a fixed position, steel stools are provided which make the plant semi-permanent.

Since it is essential to produce a large quantity of fines, a roller bearing secondary cone crusher of high output has been incorporated, and the plant is capable of producing 40-50 tons per hour of $-\frac{3}{4}$ in. medium hard stone, graded into three sizes plus rejects.

The primary unit consists of a feed hopper, plate feeder, scalping screen, roller bearing primary crusher, conveyor and diesel engine, the whole mounted on a chassis on pneumatic tyred wheels. Quarried stone may be shovel loaded to the feed hopper, and the feed to the primary crusher is controlled by a plate feeder which feeds the stone forward over a fixed bar scalping grizzly to the primary crusher. Stone which passes through the grizzly is passed on to a short troughed belt conveyor, where it is joined by the crushed product of the primary, the whole being discharged from the belt conveyor to the elevator boot. When run-of-the-primary product is required, it may be stockpiled or loaded into trucks by a portable conveyor. Where a graded run-of-the-primary product is called for, then the screening unit with portable bunker is used in conjunction with the primary unit.

The screening and bunker unit consists of a bucket elevator, triple deck vibrating screen, four-compartment bunker with retractable legs, each compartment being fitted on the underneath side with clam shell doors for lorry loading, rejects conveyor which can withdraw material from the last two compartments, and a diesel engine, all mounted on a chassis on pneumatic tyres. The product of the primary crusher is accepted into the elevator boot, raised by the elevator and fed on to the triple deck screen, where it is sized and discharged into the appropriate compartment in the bunker. The contents of either of the last two compartments can be tapped off at the side of the bunker, fed on to the rejects conveyor, and discharged into the secondary crushing unit. The raising of the bunker from the travelling to the working position is very easily achieved by two built-in winches. Jacks are not required. In the travelling position the over-all height of the bunker unit is 14 ft., and in

the working position, a clear height of 7 ft. 9 in. is left under the bunker loading doors.

The secondary unit consists of a roller bearing cone type crusher and a diesel engine mounted on a chassis on pneumatic wheels. The rejects from the bunker unit are fed into the secondary crusher and the crushed product is discharged into the boot of the elevator for rescreening.

PORCELAIN SPRAYED ON STEEL

SEAPORCEL METALS INC. is using a hand-sized spray-gun to apply porcelain material through acetylene torch, fusing it to steel, says a report of the United States Official Information Service in London. The report continues:

The company says that, although other guns have been used to spray metallised coatings, this one is the first to spray a ceramic material

The porcelain is sprayed on to the steel to form a protective coating against corrosion. Normally such fusing is done at factories in high-pressure furnaces.

The great advantage of the new method, according to the company, is that the gun is portable, which means it can be used to coat areas that otherwise could not be treated.

At the beginning of the process, the gun sends out a flame to heat the surface of the steel. Once the right temperature is reached, the porcelain mixture is blown through tiny holes in the narrow nozzle of the gun. As the material passes through the flame, it melts and is fused to the steel plate.

TRAINING FOR THE BRICK AND TILE INDUSTRY

AN interesting experiment in training, which may have considerable significance to the efforts now being taken by the brick and tile industry to attract new entrants, has just been concluded at the Ceramics Department of the North Staffordshire Technical College, Stoke-on-Trent.

At the request of the Brickworks Division of the National Coal Board a special short course suitable for foremen and undermanagers was begun in January last, and continued till the end of June. Twelve students, selected from the various divisions of the Board, were sent to the College for full-time instruction. In addition to lectures and practical work on the theoretical and practical aspects of the manufacture of bricks, tiles and pipes from the various types of clays and pit shales used in this country, the students were given instruction in the principles of foremanship, and also attended classes in elementary science. In the practical classes they were able to carry out experiments with their own clays. A very comprehensive series of works visits was an important feature of the course, thanks to the co-operation of the various managers of the Board's works, and also of private firms in this area.

Considerable interest has been aroused in the scheme and it is intended to organise a similar course during the coming winter session. Employers who are interested are invited to write to the head of the ceramics department for further details.

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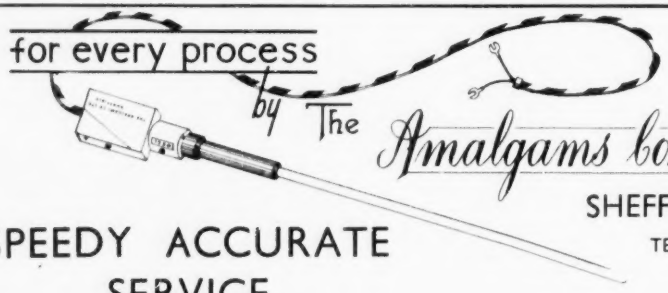

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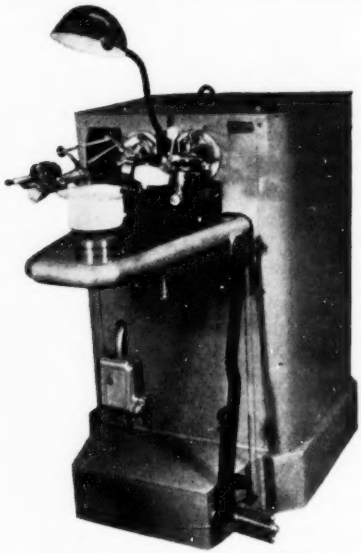

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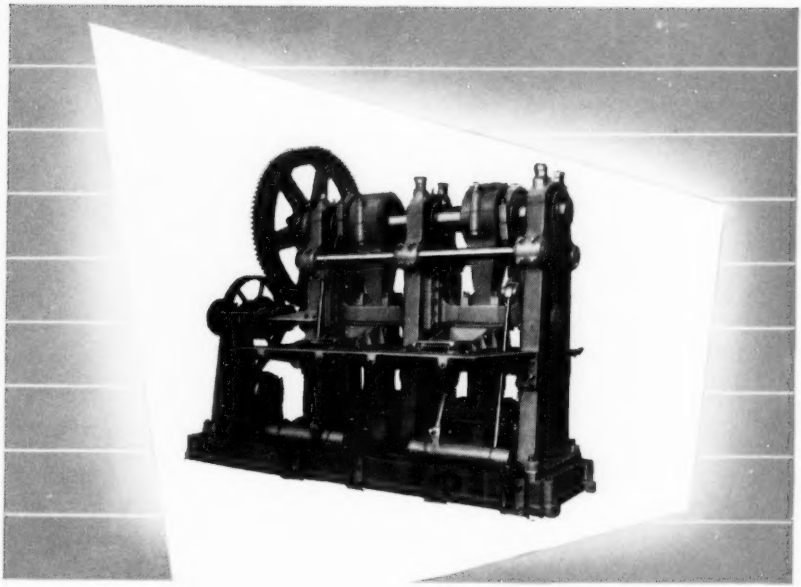

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